DOCUMENT RESUME

ED 095 923 IR 001 110

TITLE	A Feasibility Study of Computer Assisted Instruction in US Army Basic Electronics Training. Final Report.
INSTITUTION	Army Signal Center and School, Fort Monmouth, N.J.; International Business Machines Corp., Gaithersburg, Md. Federal Systems Div.
SPONS AGENCY	Army Training and Doctrine Command, Fort Monroe, Va.
PUB DATE	Feb 68
NOTE	198p.
EDRS PRICE	MF-$0.75 HC-$9.00 PLUS POSTAGE
DESCRIPTORS	*Computer Assisted Instruction; Cost Effectiveness; Efficiency; Electronics; *Electronic Technicians; Instructional Innovation; *Military Training; *Program Evaluation; Time Factors (Learning)
IDENTIFIERS	Army; Army Signal Center and School

ABSTRACT

A study of computer-assisted instruction (CAI) for US Army basic electronics training at the US Army Signal Center and School establishes the feasibility of CAI as a training technique. Three aspects of CAI are considered: effectiveness, efficiency, and applicability of CAI to basic electronics training. The study explores the effectiveness of the learning achieved by the student and the time required to complete the course material. An analysis of current training costs compared to estimates of CAI costs is used to establish the efficiency of a CAI training system. Computer-assisted instruction is shown to be applicable to Army training methods and educational strategies as well as to new communication and electronics equipment maintenance training. (Author)

A FEASIBILITY STUDY OF COMPUTER ASSISTED INSTRUCTION IN US ARMY BASIC ELECTRONICS TRAINING

FINAL REPORT

Prepared for

US CONTINENTAL ARMY COMMAND
FORT MONROE, VIRGINIA
AT THE
US ARMY SIGNAL CENTER AND SCHOOL
FORT MONMOUTH, NEW JERSEY

CONTRACT NR DAAB 07-67-C-0578
INTERNATIONAL BUSINESS MACHINES CORP.
FEDERAL SYSTEMS DIVISION
GAITHERSBURG, MARYLAND

February 1968

FOREWORD

The Department of Defense has called for demonstration of the gains that can be achieved in military training through application of the most advanced concepts and techniques extant in education and industry. This study represents an initial step in a pioneering effort to meet this challenge through user development of Computer Assisted Instruction in the electronics training program of the US Army.

The demonstration in this study of the capability of Computer Assisted Instruction to teach basic electronics subject matter as well as and in less time than conventional training are results of major significance for military training.

Conduct of the pioneering work reported on the following pages required the contribution of foresight and effort by many persons. Special thanks are due members of the Project Review Committee who provided important guidance for the conduct of the study. The members included: Captain Charles Blaschke (Office of the Secretary of Defense, Manpower); Dr. Charles Hersh (Office of the Deputy Chief of Staff for Personnel, Department of the Army); Mr. Harold Schulz and Mr. Walter McDowell (U. S. Continental Army Command).

The members of the IBM Federal Systems Division, under the leadership of Dr. Stanley Winkler, who prepared the instructional materials used in the feasibility study and performed the analysis reported in the body of this report, deserve full credit for the quality of their effort.

The United States Continental Army Command Computer Assisted Instruction Project Group at the US Army Signal Center and School played a key role in designing the feasibility study and managing its performance. Special acknowledgement must be made of the devoted efforts contributed to this work by Colonel Walter Runte, Project Manager, and Dr. Vincent Cieri, Technical Director, and by the members of their staff.

Participation of the US Army Signal Center and School in this study has been a very rewarding experience. The experience our staff has had to become familiar with the instructional uses of the computer serves as a firm foundation for the further development of Computer Assisted Instruction in electronics training.

USCONARC
CAI

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ABSTRACT

A study of Computer Assisted Instruction (CAI) for US Army Basic Electronics Training at the US Army Signal Center and School establishes the feasibility of CAI as a training technique.

Three aspects of CAI are considered: effectiveness, efficiency and applicability of CAI to Basic Electronics Training.

The study explores the effectiveness of the learning achieved by the student and the time required to complete the course material.

An analysis of current training costs compared to estimates of CAI costs is used to establish efficiency of a CAI training system.

Computer Assisted Instruction is shown to be applicable to Army training methods and educational strategies as well as to new Communications-Electronics Equipment Maintenance Training.

The evidence developed during this study, the first of its kind at an Army service school and initiated to assist USCONARC in determining the feasibility of using CAI for electronics training, has demonstrated that CAI is effective and efficient as an instructional method. It is applicable to electronics training at the US Army Signal Center and School in particular and by extrapolation to Army training in general.

SUMMARY OF RESULTS AND CONCLUSIONS

The study demonstrates and this report presents evidence for the feasibility of using Computer Assisted Instruction (CAI) as an instructional method to teach Basic Electronics which is effective, efficient, and applicable to training at the United States Army Signal Center and School and by implication to Army training in general. There are three aspects to the concept of feasibility: the learning achieved by the student, the time required to complete the course, and the cost.

The study consisted of five general tasks. The first included an evaluation of the training effectiveness of CAI compared to conventional instruction. This evaluation was performed by means of a comparative experiment which measured student learning and course completion time. As a second task, the experiment required the development of a brief CAI course. The third task was the comparison of cost effectiveness between CAI and on-going instruction. The remaining two tasks were the determination of the instructional factors and processes associated with CAI, and a review of the state-of-the-art in CAI as related to USASCS requirements.

To demonstrate feasibility, a course covering two days of instruction and consisting of 15 classroom periods of 11 hours and 15 minutes was developed and converted for implementation on the IBM 1500 Instructional System.

The evidence for the effectiveness of this implementation was based on empirical data collected under a controlled experiment which compared CAI with two types of conventional training methods currently in use at the USASCS.

From three incoming training groups of approximately 150 students a sample of 54 students in Basic Electronics Training was chosen to obtain 18 students in three aptitude levels. The students in each aptitude level were equally divided and randomly assigned to one of the three instructional modes: Instructor Controlled (IC), Television Controlled (TV), and Computer Assisted Instruction (CAI).

- o Based on the criterion measure, there was no significant difference between instructional methods. Significant differences were found in performance among students of different aptitude levels.
- o The mean time required to complete the CAI course was about 11% less than the fixed time for instructor-controlled and television-controlled instruction when all aptitude levels were included. High level students averaged 49% faster, medium level students averaged 17% faster, and low level students averaged 32% slower than those taught by conventional methods.

A comparison of CAI training costs with conventional training costs at the U.S. Army Signal Center and School was made by calculating the training costs on a cost-per-student-hour basis. The significant variables included in the CAI student hour costs were hardware costs, amortization schedules, daily system usage rates, and potential savings in student training time. Depending on system usage, depreciation policy and student selection practices, CAI costs are competitive with conventional training costs.

The applicability of CAI to USASCS training requirements in particular and Army training requirements in general was explored. The fact that a portion of the Basic Electronics Training at USASCS was effectively implemented indicates the applicability of CAI. Furthermore, the study showed that a high proportion of the current USASCS training is adaptable to CAI, that CAI state-of-the-art systems are commercially available, and that USASCS and Army training practices are currently being implemented by various CAI users.

In conclusion, the study showed that CAI is:

Effective - based on performance data, it was demonstrated that CAI was effective as training via TV and IC and reduced training time by 11%.

Efficient - under favorable decisions concerning amortization and system usage, CAI becomes cost-competitive with conventional training.

Applicable - a significant portion of existing USASCS courses is adaptable to CAI, state-of-the-art CAI systems are available, and implementation of present USASCS instructional practices have been adapted to CAI as cited in the published literature.

Based on the above criteria of effectiveness, efficiency, and applicability, the results of this study can be used to conclude that it is feasible to use CAI as an instructional method in Army training.

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Section 1

INTRODUCTION

The overall objective of this study was to provide for the United States Continental Army Command (USCONARC) the objective evidence to be used in determining the feasibility of Computer Assisted Instruction (CAI) as a medium in teaching courses in Basic Electronics. The approach employed was to assess CAI in terms of its effectiveness as a teaching method, its relativ efficiency compared with the alternatives currently in use, and its applicability to the training requirements of USCONARC.

In June, 1967, the United States Army Signal Center and School (USASCS), under the direction of USCONARC, awarded a six-month contract to the Federal Systems Division of the IBM Corporation for the conduct of this study. The products of the study were to provide empirical data on the effectiveness of an actual CAI implementation using students taken from the normal population of students obtaining Basic Electronic training at USASCS and to provide detailed information and guidelines which would be useful to USCONARC in determining the desirability of proceeding with the USCONARC Technical Development Plan (TDP) entitled "Computer Assisted Instruction in Electronics Training," dated 12 August 1966.

To assess the effectiveness of CAI as an instructional method, it was necessary, first of all, to implement a portion of the Basic Electronics training on a CAI system. The course segment selected was the material taught on Thursday and Friday of the first week in the Common Subjects Branch. It includes the material in the lesson plan set 280.0-1-LP(25-38), dated January 1967, under the following titles:

a. Introduction to Electricity (280.0-1-LP(25-27)
b. Care and Use of the Multimeter (280.0-1-LP(28-31)
c. Batteries (280.0-1-LP(32-34)
d. Resistors (280.0-1-LP(35)
e. Resistor Applications (280.0-1-LP(36-38)

The selection of this material was based on several considerations. As a part of the first two weeks of instruction, the material is taught to all students preparing for a Military Occupational Specialty (MOS) in the school, thereby offering a large population from which to draw a student sample. The material includes definitions, terminology and concepts basic to any further work in the school. The material is not dependent upon previous training and thus teaches students not affected by the instructional methods currently employed.

The CAI course was developed for presentation on the IBM 1500 Instructional System. The student station for this presentation consisted of an IBM 1510 Display Console (cathode ray tube -- CRT, light pen and keyboard) and an IBM 1512 Image Projector for colored graphic presentations.

It was decided that the effectiveness of this implementation should be compared with two methods of conventional instruction, Television-Controlled (TV) and Instructor-Controlled (IC). To be sure that only the mode of presentation would vary, the CAI course was developed to meet the same course performance objectives used by the other two methods.

For the comparison, a number of other controls were implemented to ensure the objectivity of the conclusions. A sample of 54 students was selected from the total population of USASCS students to represent the range of aptitudes found at the Signal School. Equivalent groups of 18 students were assigned to each of the three instructional methods. The effectiveness of instruction by each of these methods was measured by an 85-item multiple choice paper and pencil test developed from the course performance objectives. In addition, the time required by the CAI students to complete the course was compared with the fixed time required for the students taught by the conventional methods as established by the lesson plans.

The implementation of the course materials and the results of the comparison of effectiveness provide evidence to USCONARC that CAI is an effective method of teaching Basic Electronics. Of necessity, this study effort was limited. Time constraints allowed for the implementation of only a small segment of the Basic Electronics course, and only a small number of students could be used to evaluate the implementation.

As a demonstration of the efficiency of CAI, a cost analysis was conducted. The cost of current training at USASCS was compared with the estimated cost of a CAI instructional system. It would be naive to

expect that, in its current state of development, CAI could be shown to have a cost advantage over an established training organization. On the other hand, if CAI, in fact, is so expensive that future developments could not be expected to make the method cost-competitive, then it would be undesirable to undertake a major CAI effort. The purpose of the cost study was to identify those elements of CAI which are significant in cost and to evaluate their effect on the cost model. For comparison, the current training costs at USASCS were calculated, based on data supplied by the Signal School. Costs were distributed to a student-hour of instruction. CAI costs were calculated as well as possible with the data available, and comparisons made for various decisions on amortization, depreciation, and distribution as well as the effect of system utilization and possible savings in training time.

Finally, the task of demonstrating that CAI is applicable to the training requirements of USASCS in particular and the Army in general was addressed. Obviously, the effective implementation of a portion of a USASCS training course was a first step in this demonstration. In addition, the resource requirements needed by USASCS to begin implementation of the USCONARC TDP are identified. A general hardware configuration is described, and the number and type of personnel required to implement and maintain instructional materials and to operate the system equipment are listed. Three commercial CAI systems currently available for delivery are described. It is noted that these systems would meet the hardware requirements which had been outlined. Two courses, one representative of Basic Electronics training and one representative of New Equipment Training, were analyzed to determine the methods of instruction currently in use. Based on this analysis and experience in implementing CAI, the proportion of existing courses which could be converted to CAI was estimated.

Consideration was also given tothe identification of instructional factors and processes relevant to CAI in Basic Electronics training. It was admitted that no instructional methodology can ever completely replace the unique capabilities of the human instructor. Even the versatility of CAI, though remarkably adaptive, has practical limitations and will fail to be all things to all students. By using CAI, however, many of the instructional practices which currently consume substantial amounts of the instructor's time can be handled on the system, freeing the instructor to attend to individual student problems. Furthermore, CAI provides individually paced instruction and student administrative data used in course management. Three general categories of these practices were identified and examples of how they are being handled by CAI in other institutions presented and referenced to Army requirements.

In summary, this study was designed to produce evidence of the effectiveness, efficiency and applicability of Computer Assisted Instruction for training students in Basic Electronics. Each of the three following parts of this report presents, in detail, the procedures, results and conclusions of this study as they apply to the effectiveness, efficiency, and applicability of CAI.

Section 2

EFFECTIVENESS OF COMPUTER ASSISTED INSTRUCTION

This portion of the study was designed to assess the effectiveness of Computer Assisted Instruction as a training method. Specifically, the question addressed was whether or not CAI could be used to teach a portion of the Basic Electronics course in the Common Subjects Branch of USASCS. The instructional material selected was described in the introduction to the report.

Six tasks were required to produce an objective evaluation of the effectiveness of CAI. First, it was necessary to implement the course material on the IBM 1500 Instructional System. Since the effectiveness and, to some extent, the efficiency of CAI was to be measured by this implementation, these factors had to be considered in designing the course logic. Because of the limited time for the implementation, it was necessary to evolve efficient implementation procedures. Second, the decision to compare CAI effectiveness with two modes of conventional instruction (TV and IC) required that the methods had to be defined and the course content under each method made equivalent. Third, a device to measure the student's performance as a result of this instruction had to be devised with due consideration to the problems of reliability and validity. Fourth, it was necessary to define the student population in terms of aptitude and to evolve a sampling procedure which would produce a sample of students representing the range of aptitude of USASCS. Fifth, a detailed procedure for administering the training under the three instructional methods was required. Finally, the data from the performance measure had to be analyzed and interpreted.

This part of the report describes the procedures that were followed to accomplish each of these tasks and the results that were obtained. The implications of these results in terms of the effectiveness of CAI as an instructional method are discussed.

2.1 COURSE DEVELOPMENT

The material used for this study was identified in the introduction to the report. The material was selected by joint agreement between USASCS and IBM Federal Systems Division. Since the IBM 1500 Instructional System was designed specifically for CAI it was agreed that this system would be made available for use in the study. Figure 2-1 illustrates the student station of the 1500 System.

Special attention was given to ensure that the CAI course material was similar in content to the material presented in the instructor-controlled and television-controlled classrooms. Three steps were taken to assure equality of subject coverage. IBM personnel were provided with complete lesson plans and other relevant instructional material; they were also given the opportunity to observe the conventional instruction in the classroom. Secondly, the terminal performance objectives for the material were provided for IBM. Finally, the CAI course lessons were reviewed by Signal School personnel for equivalence and accuracy.

The development of the course material was begun by organizing the material into subject matter areas called course segments. The CAI course segment consisted of a pretest and a series of lessons. The pretest was provided to determine the amount of information which the student brought to the training situation. Following the pretest, a series of lessons presented the new material. Each of the lessons concluded by a lesson test and if necessary additional summary material.

The structure of the course can be outlined as follows:

Segment I Introduction to Electricity

Lesson 1. Use and purpose

Lesson 2. Survey

Practical Exercise-Survey

Lesson 3. Electron Theory

Lesson 4. Voltage

Lesson 5. Resistance

Lesson 6. Current

Figure 2-1. Students at IBM 1500 Instructional System Station

Segment II Multimeter TS-352/U

Lesson 1. Introduction

Lesson 2. DC Voltage

Practical Exercise-DC Voltage.

Lesson 3. AC Voltage

Lesson 4. DC Current

Segment III Batteries

Lesson 1. Introduction

Lesson 2. Series Connection

Lesson 3. Parallel Connection

Lesson 4. Series - Parallel Connection

Segment IV Resistors

Lesson 1. Introduction

Lesson 2. Color Code

Lesson 3. Ohmmeter

Practical Exercise-Batteries/Ohmmeter

A student's path through the course was determined by his performance on the pretest and lesson tests. The pretest was used to improve the efficiency of the instruction. Since the pretest consisted of groups of questions related to the lessons that followed, the student's performance on the pretest was used to present to him only that material which he required. If, in the pretest, the student demonstrated proficiency with the various skills or concepts taught in the segment, he skipped the lessons covering those skills and concepts. When, however, he failed a group of pretest questions, he branched to the appropriate lesson and continued to the end of that course segment.

The lesson test was used to improve the effectiveness of instruction. Following the instructional material, the student was presented with the opportunity to demonstrate that he had learned the material.

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I. the instructional material had not been effective in teaching the skills and concepts he required, the student was presented with reviews and summaries to assist him. In no case was the student allowed to proceed until he had given the required response to the lesson test questions.

In spite of the time restrictions imposed by a six month feasibility study, several unique features were included in the course strategies to indicate the adaptability of CAI to various training requirements. Of primary importance was the development of practical exercises which became an integral part of the CAI training. At three different points in the short training course the student actually manipulated electronic components and equipment under the guidance of the CAI system. As an example, when learning about resistors, the student actually measured resistor values using Multimeter TS - 352/U. He entered his obtained readings into the system, where they were evaluated. If his responses did not indicate that he had reached the desired proficiency, he was given additional guidance and practice.

To maintain student interest, the mode of presentation of the course material was varied. One of the most unique variations was the use of animation on the CRT. When learning about the attraction and repulsion of charged bodies, the student was presented with an animated demonstration that like charges repel and unlike charges attract. To provide the student with reference material when he needed it, a glossary was implemented. If the student was unsure of the meaning of a technical term, he could request the glossary and ask for a definition of that word. He was given the definition and then returned to the instructional material. To emphasize technical terms and assist the student in learning them, such terms were often underlined or caused to blink on and off on the CRT when they were first presented.

No claim is made that the strategies and technique used in this implementation were optimal nor that they fully exploited the potential of CAI. However, within the time and resource limitations of this feasibility study, they answered the requirements of effectiveness and efficiency and gave some indication of the wide applicability of CAI to electronic training. Appendix A presents a detailed description of the procedures employed in developing the course and a complete documentation of the resultant course (page A-1 ff.).

2.2 THE INSTRUCTIONAL METHODS

The independent variable of primary interest in assessing the effectiveness of the CAI course was the method of instruction. Three methods were compared: Television-Controlled (TV), Instructor-Controlled (IC), and Computer Assisted (CAI). Television-Controlled instruction was defined as the method of instruction currently in use in the Common Subjects Branch of the School. It included the use of video-taped presentations, programmed instruction, practical exercises, and conference time. The Instructor-Controlled Instruction was similar to the Television-Controlled, with a change of emphasis from video tape to conference time (Table 2-1).

Table 2-1

COMPARISON OF TV AND IC INSTRUCTIONAL METHODS

	% of Total Time	
Media	TV	IC
Television	38	20
Programmed Instruction	21	21
Conference	9	27
Practical Exercise	32	32
	100	100

CAI was defined as an implementation, using the IBM 1500 Instructional System, of the same course material on a computer-controlled system.

Within each of the three instructional methods, the actual course content remained constant relative to the list of course objectives. The order and details of presentation varied somewhat from method to method.

Since the TV and IC methods depended on the skill of the instructors used in the classroom, it was necessary to control this skill factor to avoid a differential effect between the two methods. Two pairs of instructors were selected from among those considered to be above average. Thus the CAI method could be compared with the other two methods at

their best, and any advantage which might accrue to the CAI method would be valid for the usual situation in which average instructors are used.

The matching procedure was based on subjective agreement among USASCS personnel from the Evaluation Division, the Instructional Methods Division (IMD), and personnel from IBM who reviewed the rating cards of those instructors available for the study. The instructors were matched, as closely as possible, on the basis of formal education, teaching experience, grades in the Instructor Training Branch, IMD, and subsequent ratings as instructors.

It would have been more desirable to attempt to objectively measure instructor skill. However, within the time available, such an approach was not feasible and the procedure actually used was adopted as the most practical alternative.

2.3 MEASURES OF EFFECTIVENESS

The main measure of effectiveness of the instructional methods was a score on the criterion measure. Ideally, the effectiveness of training should be based on some measure of job performance. However, when, as in the present case, the training is remote in time from an opportunity to measure job performance, an alternative procedure must be developed. The alternative for this study was to develop an 85 item 4-alternative multiple-choice criterion measure based on detailed behavioral objectives of the course material selected.

2.3.1 Criterion Measure

An original draft of 130 items, developed from the lesson plans, was administered to 207 students who had just completed their first week of training at the School. Item selection was based on these data. Two measures were computed for each item—a difficulty level, which was the percentage of students answering the item correctly; and a discrimination index, which was a measure of how well the item discriminated between the upper and lower 27% of the sample.

Items for the final draft were selected first on the basis of difficulty level. Where guessing by the student has no effect, a difficulty level of .50 maximally discriminates among the students. In a 4-alternative multiple-choice item, guessing does have an effect and the difficulty level must be raised to correct for it. Therefore, a difficulty level of .65 was chosen as the desired average difficulty for the items.

Those items selected on the basis of difficulty level were further selected on the discrimination index. An index of .20 was chosen as the minimum value which indicated any discrimination in performance between the upper and lower groups. These values were used as guidelines rather than absolute limits, and some items were included which did not meet these criteria. Some items which were quite easy (difficulty .95) and some items which were quite difficult (difficulty .14) but had little discrimination were included, to ensure that the test extended beyond the capabilities of the students in both directions.

The second draft of the criterion measure contained 85 items. These items covered definitions and concepts as well as performance measures, such as reading resistor color codes, reading scales on the multimeter, and recognizing schematic symbols and simple battery circuits. There were nineteen items on each of the four major segments of the course material and nine items covering the conversion of units, a total of 85.

The criterion measure was evaluated in terms of validity and reliability. Validity refers to the test measuring what it is supposed to measure. Without an objective measure of validity, the approach was to ensure that the criterion test measured as much as possible the students' knowledge of the course material. To this end, each item was referenced to one or more of the course objectives. As a precaution against possible bias, the final draft was submitted to the Department of Specialist Training, USASCS, for review. When their minor revisions were included, the Department of Specialist Training concurred with the measure. While this validation procedure is based on subjective agreement, it was felt that it produced an appropriate and impartial measuring device.

The reliability of a measuring instrument refers to the consistency of the measurement. Every measurement contains some error, and its magnitude should be assessed. In educational measurement it is not possible to measure error directly, but methods are available by which it can be estimated. A widely used procedure (split-half method) is to divide the measuring device into two halves, calculate a score for each student on each half, and compute the correlation between the two sets of scores. A second method (Kuder-Richardson) is based on item statistics and is not dependent on any particular subdivision of the measuring device. A reliability coefficient of .80 is generally accepted as an indication of satisfactory reliability. It indicates that the variance due to error is one-fourth as large as the true variance of the scores.

The [illegible] criterion measure was administered to 95 students who had just completed their first week of training at the school. The split-half reliability from these data was .90, and the Kuder-Richardson reliability was .87. Both coefficients indicated acceptable reliability. The average difficulty level of the items was .67.

2.3.2 Student Training Time

A second measure of the effectiveness of the training methods was the length of time it took the students to complete the course. Since training time has a direct bearing on the efficiency of an instructional method, this variable was of particular interest in the feasibility study. The Television-Controlled and the Instructor-Controlled methods each required 11 hours and 15 minutes, as set by the lesson plans referenced in the Introduction. It was estimated that a student would require a minimum of two and one half hours to complete the CAI course. Since the actual amount of time spent on the course material with the CAI system was essentially student controlled, there was no maximum time for this method. The time measure used in the CAI method was the actual time used by the student at the terminal. This information was available as part of the software support for the system and appears in the student records.

To obtain a precise comparison between the times of the instructional methods, only that time actually spent on instruction was considered. Thus time for roll call, testing, administrative procedures, etc., was excluded from the time data.

The distributions of times in the CAI method was not completely a function of the student control. In addition to the minimum time imposed by the course logic, the particular implementation used for this study placed constraints on the shape of the distribution of student time. However, within these constraints, the times did vary from student to student, and the time measurements provided useful data.

2.4 THE STUDENT SAMPLE

A total of 54 students was used in this study, 18 for each of the three instructional methods. All of the students were selected from the normal inputs of draftees and Regular Army students to the Common Subjects Branch with the exception of turnbacks and students in the 41 series MOS's. The turnbacks were excluded because of the complications involved in using students who had previous training at the school and who had also once failed the material. The 41 series MOS's entering the Common Subjects Branch were excluded because these students are not selected by Electronics Area Aptitude score (EL score).

2.4.1 Aptitude Levels

The students used in the study were selected by means of a stratified random sampling procedure to represent three levels of aptitude — low, medium, and high. Student aptitude was measured by a predicted USASCS Phase I test score. The Phase I test mentioned in this report is given the student at the end of the second week of training in the Common Subjects Branch of the Radar Division in the Department of Specialist Training. The prediction was based on a linear combination of four of the subtest scores from the Army Classification Battery (ACB). The equation used to predict the Phase I test score was generated by a multiple linear regression procedure. This procedure produces the linear equation which is the best predictor because errors of prediction are minimal. An initial equation is calculated, using the independent variable having the highest correlation with the dependent variable. With this equation, the residuals, i.e., the differences between the actual and predicted Phase I scores, are calculated. A second equation is generated using the first independent variable and adding a second independent variable which has a high relation with the residuals. This process is continued until all the variables are used.

Applying this procedure to a sample of approximately 1000 students at USASCS produced an equation containing four independent variables and the appropriate weightings to be applied to each. The addition of more variables to the equation did not improve the accuracy of prediction. The predicted Phase I scores correlated .66 with the actual scores. This correlation indicates that approximately 44% of the variance in the Phase I test scores is accounted for by the ACB scores used. The final equation was:

$Y = .34ELI + .31AR + .18PA + .05ARC - 1.23$, where:

Y is the predicted Phase I score,

ELI is the score on the Electronics Information subtest,

AR is the score on the Arithmetic Reasoning subtest,

PA is the score on the Pattern Analysis subtest,

ARC is the score on the Army Radio Code subtest.

During each of the weeks the study was run, selection scores were calculated for the entire student population entering common subjects with the exceptions noted above. The distribution of selection scores was divided into five groups as follows:

Group I, low aptitude,	scores of 85 or less
Group II,	scores of 86 to 100
Group III, middle aptitude,	scores of 101 to 103
Group IV,	scores of 104 to 116.
Group V, high aptitude,	scores of 117 or more

2.4.2 Sampling Plan

A minimum of eight students each was randomly selected to represent Groups I, III, and V. Half of the students from each group were randomly assigned to the TV class and the other half to the IC class. The remainder of the two classes was filled at the convenience of the registrar. The CAI students were taken from the TV and IC classes. In each of the two classes, one student from each aptitude level was selected at random for training with CAI. Thus, three students from the TV class, one at each aptitude level, and three from the IC class, one at each aptitude level, constituted the CAI group during each week of the study. Three students, one at each aptitude level, in each class were selected as alternates. This procedure was replicated for three weeks. The total sample of 54 students consisted of 18 from each aptitude level, evenly divided among the instructional methods. A diagram of the overall design is shown in Table 2-2. Descriptive data on the student sample is presented in Table 2-3.

Table 2-2

EXPERIMENTAL DESIGN

Aptitude Levels	Instructional Methods			
	CAI	TV	IC	
High	6	6	6	18
Medium	6	6	6	18
Low	6	6	6	18
N	18	18	18	54

TABLE 2-3. DESCRIPTIVE DATA ON STUDENTS USED IN THE CAI FEASIBILITY STUDY

Aptitude Level	Instructional Method	Age		Education		El. Score		Predicted Phase I Score	
		Mean	Range	Mean	Range	Mean	Range	Mean	Range
Low	CAI	19.5	17-21	11.7	10-12	105.0	98-112	81.8	76-85
	IC	19.7	17-21	11.7	10-12	102.5	98-107	80.7	73-85
	TV	19.3	18-21	12.0	-12-	108.7	101-125	81.0	74-85
Medium	CAI	19.7	17-21	13.0	12-15	117.7	110-127	102.2	101-103
	IC	19.5	18-20	12.5	12-14	117.5	105-127	102.2	101-103
	TV	20.5	19-24	12.8	12-16	115.7	111-120	101.7	101-103
High	CAI	19.5	19-20	13.0	12-14	138.0	130-149	121.2	117-127
	IC	20.8	20-23	13.5	12-15	135.5	128-143	119.2	117-122
	TV	19.8	18-22	13.2	12-15	139.0	129-149	119.3	117-121

2.5 ADMINISTRATIVE PROCEDURES

On Monday of each week that the study was run, the selection procedure described above was carried out and two rosters were constructed. The rosters listed those persons who were to be placed in the TV and IC classes. The classes as constituted by the USASCS Registrar were held intact through Tuesday noon so that orientation could proceed by MOS. At the completion of orientation the necessary shifts in student personnel were completed to place the selected students in the proper classes.

At the completion of instruction on Tuesday afternoon, the criterion measure was presented as a pretest to each class used in the study. None of the course material selected for the study was presented to the students on Monday or Tuesday. Therefore, the scores on this pretest represented that information which the student had before the start of instruction.

Following class on Wednesday, the CAI students were transported to Annapolis, Maryland. That evening they were instructed in the use of the student terminal and allowed approximately 15-20 minutes to familiarize themselves with the various features and procedures.

On Thursday and Friday, the CAI students used the student stations to learn the course material. Initially the students were divided into two groups of three students, one from each aptitude level. The first group used the terminals from 8 to 12 in the morning and 4 to 8 in the evening. The second group used the terminals from 12 to 4 in the afternoon and 8 to 12 at night. On Friday, adjustments were made in the schedule to put those students who were progressing more slowly on the terminals in place of those who had completed the work.

For the second and third weeks, the schedule was altered so that the first group used the terminals from 8 to 12 and 5 to 8. The second group used the terminals from 12 to 5 and 8 to 10. On the second day the same flexibility was used. The reason for the change in scheduling was the observation during the first week that the second group of students was tiring in the evening and that possibly time was not being used productively.

The students proceded at their own rate because presentation of material was under their control. A proctor was present in the terminal room to assist the students if necessary. His actions and procedures were determined by the proctor instructions which are appended to this report (Appendix B). In actuality, his communications with the

students were generally in an administrative capacity and he made few, if any, inputs to the instructional process. All contacts and observations made by the proctors were entered on a log. A sample of the proctor log is shown on Appendix B-13. When the student completed the course material, he was given the criterion measure as a post test. The students were returned to Fort Monmouth on Saturday and rejoined their classes on Monday morning.

The non-CAI students followed the normal class on Thursday and Friday. Immediately following the end of instruction on Friday, the criterion measure was administered to the two classes as a post test.

2.6 RESULTS AND ANALYSES

At the outset it was necessary to determine if the students in the three instructional methods began the instruction with the same amount of prior knowledge of the course material. The three groups were compared using the pretest scores as a measure of the prior knowledge. The summary data is presented in Table 2-4.

Table 2-4

SUMMARY OF PRETEST DATA

METHOD	MEAN	S.D.	APTITUDE LEVEL	MEAN	S.D.
TV	32.4	12.8	High	49.1	10.3
IC	33.9	14.8	Medium	30.0	10.2
CAI	37.0	14.1	Low	24.3	4.9
TOTAL	34.5	13.8			

To evaluate the significance of the observed differences among the means, the analysis of variance procedure was used (Cochran and Cox, 1957; Lindquist, 1953). This analysis compares the observed differences among the means with the variance of the total sample corrected for the effects of instructional method and aptitude level. The statistic used is the F ratio with which the probability of obtaining a given result from chance alone can be determined. The results of this analysis are given in Table 2-5.

Table 2-5

ANALYSIS OF PRETEST DATA

SOURCE	d. f.	MEAN SQUARE	F RATIO	p
Instructional Method	2	97.02	1.19	n. s.
Aptitude Level	2	3044.02	37.49	.001
IM x AL	4	39.80	0.49	n. s.
Residual	45	81.20		
TOTAL	53			

d. f. = degrees of freedom
n. s. = not significant
p = probability

The right column in Table 2-5 gives the probability of obtaining differences as large as those observed by chance alone. The notation "n. s." indicates that the differences observed do not approach the usual 5% or one chance in 20 probability level. Thus, the differences observed among the scores of the students assigned to the instructional methods are considered to be merely chance fluctuations, and the assumption that the three groups of students began the instruction with comparable amounts of prior knowledge of the course material is not disproved.

A second comparison of interest is the interaction between instructional methods and aptitude level (IMxAL). The lack of significance in this F ratio indicates that the aptitude levels were equivalent across the instructional methods. This supports more fully the assumption of equal amounts of prior knowledge.

The differences observed among the aptitude levels would occur in less than one sample in 1000 by chance alone. That these differences are highly significant is not surprising in view of the use of the ELI subtest in selecting these students.

One factor which complicates the analysis is the failure to meet the assumption that all of the variances are equal (homogeneity of variance).

As can be noted in Table 2-4, the variance of the low aptitude group is much less than the other variances. The effect of failing to meet this assumption is an increase in the mean square term for the aptitude levels. This results in an overestimation of the F ratio for that partition and an overstatement of the significance of the differences. The magnitude of this inflation of the F ratio is difficult to calculate but, considering the absolute differences among the means, it does not affect the interpretation. If the F ratio were reduced by a factor of 10, it would still be significant (Eisenhart, 1947; Lindquist, 1953, page 78).

With these data to substantiate the assumption that the students began on an equal basis, the post test scores should reveal the effects of the instructional methods. Table 2-6 is a summary of the post test. scores.

Table 2-6

SUMMARY OF POST TEST DATA

METHOD	MEAN	S.D.	APTITUDE LEVEL	MEAN	S.D.
TV	57.4	15.2	High	74.2	3.0
IC	55.7	18.9	Medium	58.3	8.8
CAI	60.2	14.4	Low	40.78	11.3
TOTAL	57.8	16.1			

To evaluate these results the analysis of variance procedure was used and the results of this analysis are presented in Table 2-7.

Table 2-7

ANALYSIS OF POST TEST DATA

SOURCE	d.f.	MEAN SQUARE	F RATIO	p
Instructional Method	2	90.39	1.27	n.s.
Aptitude Level	2	5037.56	70.86	.001
IM x AL	4	64.11	0.90	n.s.
Residual	45	71.09		
TOTAL	53			

The results of this analysis are essentially the same as the pretest scores. There were no significant differences among the instructional methods nor in the interaction between aptitude level and instructional methods. There were highly significant differences among the aptitude levels, as would be expected. Thus, it is concluded that, on the average, this CAI course was as effective in teaching these students as either the IC or TV methods. Also, there was no difference in the effectiveness for the three instructional methods at any of the three aptitude levels.

Finally, the time required for the CAI students to complete the course was obtained from the student performance recordings on the system. These data are summarized in Table 2-8.

Table 2-8

SUMMARY OF CAI STUDENTS' COURSE TIME

GROUP	MEAN		RANGE			
	Hours	Min.	Hours	Min.	Hours	Min.
High Aptitude Level	5	43	3	55 to	6	36
Medium " "	9	22	7	01 to	11	00
Low " "	15	00	9	39 to	17	52
Total Group	10	02				
Weighted Average	9	58 = 88.5% of 11 hrs. 15 min.				

As can be seen from Table 2-8, time to complete the course appears to be related to aptitude level. This reflects the course strategy of pretesting and skipping students over material which they already know. The pretest data showed that the amount of knowledge prior to instruction was related to aptitude level, and this effect is shown in the data. If it can be assumed that time to complete the course is related to aptitude, then to infer from these data to the Signal School population it is necessary to weight the obtained averages by their proportionate representation in the population. The high and low aptitude levels each represent 7% of the population and the medium aptitude level 9%. With the appropriate factors, the weighted average for the group is 9 hours 58 minutes. This represents an 11.5% saving in time over the conventional instruction time of 11 hours 15 minutes for the TV and IC methods.

Of the 18 CAI students, 13 of them (72%) completed the course in less than the 11 hours and 15 minutes. The other five students, all from the low aptitude level, required from 14 to 18 hours to complete the course.

2.7 REVIEW

The results of this study demonstrate that a course of instruction implemented on the IBM 1500 Instructional System is as effective in teaching students from the Signal School population as are more conventional instructional methods (IC and TV). In addition, the CAI course taught the material in less time.

In interpreting the results, several factors should be considered. Students who are selected for a different treatment do not behave in precisely the same manner as they otherwise might; they tend to perform in a superior fashion. Since the CAI students knew that they were being treated differently, this "halo" effect probably produced better performance from these students. Additionally, because of scheduling, the CAI students could review and study during the day. The USASCS Evaluation Division Personnel who handled the CAI students felt that the students used this study time and thus might have improved their performance. These two factors may have some effect on this particular CAI course. Unfortunately, the magnitude of the effect cannot be measured, but its presence should be considered in the evaluation.

On the other hand, these results should not be considered as a general evaluation of CAI. Limitations in the effort, due mainly to time constraints, prevented the development of a CAI course which uses all the unique capabilities of the system. Only limited branching was employed, and the course strategy must be considered as a first approximation. No significant revision of the course, based on student response data, was possible and thus one of the major advantages of CAI was lost.

However, taken in the context of a feasibility study, the results do demonstrate that CAI is effective as an instructional method. Course material can be implemented on the IBM 1500 Instructional System to teach USASCS students the same amount of material in less time than conventional methods.

Section 3

EFFICIENCY OF COMPUTER ASSISTED INSTRUCTION

The training activity of USACS at Fort Monmouth is similar in many respects to a manufacturing process. This training activity can be divided into similar and comparable units such as: an input, the untrained student; a process, the instruction process; and an output, the student graduate. If the process is analyzed from a pure cost approach, the objective would be the production of qualified graduates at the least cost. To achieve this objective, the capability of adequately determining the cost of producing graduates would be of prime importance. This requires the accumulation of instructional process costs in useful classifications whereby cost comparisons of various instructional process alternatives are possible.

The specific cost analysis objectives of this study are to estimate the cost of producing student graduates via the conventional instruction process currently used at USASCS, to determine the significant cost factors applicable to the computer-assisted instruction process, and to develop a methodology for determining the relative cost effectiveness of an IBM 1500 CAI system versus conventional training.

3.1 COST RELATED VARIATIONS OF THE TRAINING PROCESS

The process of instruction may be varied in several ways relating directly to costs. These variables are of primary concern in achieving the objective of producing qualified graduates at the least cost. Foremost among these is the reduction of training time involved in the instruction process. A large percentage of training costs at USASCS could be classified as period costs, i.e., costs incurred over a period of time, such as instructor pay, student pay, and logistic support. It appears that a reduction in training time should result in reducing the cost of producing student graduates.

Another important element is student attrition. Student attrition, whether in the status of "recirculation" (repeating a unit of the course) or failure, represents additional or lost training time. In either circumstance, the cost of this training time increases the total cost of the

training process and ultimately the cost of producing course graduates. Therefore, an instruction process change that successfully reduces student attrition should also reduce student graduate costs.

Still another important element is reducing waiting time to a minimum. In a conventional school environment, considerable time is lost waiting for classes to form, waiting for assignment to classes, fast students waiting for slow students to catch up, etc. Reduction of waiting time should result in the reduction of the cost of producing student graduates.

A fourth important element is the improvement of student performance. This item is not so easily related to cost as the previous three items. In one respect it is analogous to attrition because improvement in student performance should result in reduced student attrition. The ability of a teaching process to successfully teach students of low achievement and to increase the knowledge and retention of all students is an additional important element in student performance. The cost of instructing these groups would be directly related to the length of time it takes to train the individual. In this particular consideration, the cost of training the low achievement groups may be of lesser importance than the potential value of having the capability to upgrade the training of this group to higher level skills.

The cost involved in these four variables is, of course, the accumulation of many smaller cost items that make up the composite cost of any training system. All four variables relate to training time and the ability of a training process to produce qualified graduates in minimum time. The success of a highly efficient training system that produces qualified graduates in less time than conventional training methods potentially offers a reduction of the training "pipeline" (number of people in training process) yet will provide the requisite number of school graduates.

It is with the details and the comparative relationships of the composite training costs that this analysis is concerned.

3.2 GENERAL COST ANALYSIS DESIGN

The overall design of this cost analysis requires identification of the cost of CAI and conventional training, and the grouping of these costs into comparable classifications. The costs are then consistently distributed by the most logical means to a common unit, the "student instructional hour." This common unit provides a useful tool with which the cost of

producing course graduates can be calculated by simple arithmetic for either instruction method or for combinations thereof. The student instructional hour used throughout this analysis is based on present USASCS class schedules.

3.3 TRAINING PROCESS ALTERNATIVES

The first steps in the analysis is to establish the alternatives under consideration. The alternatives are identified as follows:

a. Cost of CAI instruction system
b. Cost of conventional instruction system at USASCS
c. Cost of combinations of a and b.

Some of the general cost considerations that should be accounted for when attempting to analyze the costs of a training system are discussed in the following paragraphs.

The total cost of implementing the system should be within the fiscal means of the sponsor or user. The system should be capable of meeting performance objectives and be cost-competitive with other available training systems. These are basically the tests of usefulness and practicality since an instructional system that does not effectively teach the subject matter is of questionable usefulness no matter how low the cost. Also, the cost of a highly effective system that exceeds fiscal feasibility is of questionable practicality.

The usefulness and practicality of the alternatives under consideration should be determined in terms of cost and effectiveness. It is important that the third alternative be considered since the path of optimal cost and effectiveness may be a combination of the two systems.

Evidence of effectiveness in regards to the abilities of the systems to aid the student learning process is presented in Section 2 of this report. Appendix C provides the details of the cost analysis of the above alternatives.

3.4 COST - EFFECTIVENESS ANALYSIS

3.4.1 Cost-Comparisons

The cost of producing graduates using a system such as CAI which requires the outlay of large amounts of capital initially will be most cost-

competitive only when this system is used to its full capacity and capabilities. In addition, the schedule selected for depreciation of these costs has significant impact on cost competitiveness. The capabilities of the IBM 1500 Instructional System in areas other than CAI, such as data processing, should be included for total system cost-effectiveness considerations.

The following table shows a comparison of the ranges of cost of producing course graduates by a CAI system without the USASCS costs of conventional training environment, the CAI system installed at USASCS, and the current conventional instruction costs of course 26L20 at USASCS.

Table 3-1

COST OF GRADUATE IN 840 HOUR COURSE (26L20)

Use of CAI system per school day	6 hrs.	12 hrs.	18 hrs.
CAI System			
5 yr. depreciation	$3343	$1873	$1378
10 yr. depreciation	$2167	$1285	$ 991
CAI System at USASCS			
5 yr. depreciation	$6923	$5453	$4958
10 yr. depreciation	$5747	$4865	$4571
Conventional Instruction		$4, 092	

Data is based on 32-terminal IBM 1500 Instructional System

It appears that the CAI system is cost-competitive in all cases where there is no conventional training environmental cost involved. When the system is installed in a conventional environment there appear to be no cost-competitive examples. Under these circumstances in order for the system to be cost-competitive, a reduction in training time must

be achieved. Impact of attendant cost reduction with reduction in training time at USASCS is as follows:

Table 3-2

COST OF COURSE GRADUATES WITH REDUCTION IN 840 HOUR INSTRUCTION TIME

Use of CAI system per school day	6 hrs.	12 hrs.	18 hrs.
5 yr. depreciation			
10% Reduction time	$6232	$4909	$4463
20% Reduction time	5538	4362	3965
30% Reduction time	4847	3818	3471
10 yr. depreciation			
10% Reduction time	$5173	$4380	$4115
20% Reduction time	4597	3891	3656
30% Reduction time	4024	3407	3201
Conventional Instruction		$4,092	

Data is based on 32-terminal IBM 1500 Instructional System.

The area of cost-competitiveness is achieved with a reduction of 30% in training time and 12 hours per school day utilization if a 5-year depreciation is selected. If a 10-year depreciation is elected, cost is competitive at approximately a 20% reduction in training time and utilization of 12 hours per school day.

The cost data used in this analysis are only as reliable as available data would permit but are considered accurate enough to provide a general overview of the various cost relationships and demonstrate the feasibility of the methodology described (Appendix C has details).

3.4.2 Cost-Effectiveness

In examining the three alternatives under consideration for analytical purposes, it is important to know the maximum efficiency of the system. For example, it costs an estimated $4,092 to train a student in course 26L20 at USASCS. The academic attrition rate is 12.3% (USCONARC,1967). This represents inefficiencies in the system and results in increased cost of producing course graduates. If there were no attrition, it is estimated that course graduates could be produced at approximately $3800. Thus, the difference between these costs is equal to the cost of the inefficiencies of the system.

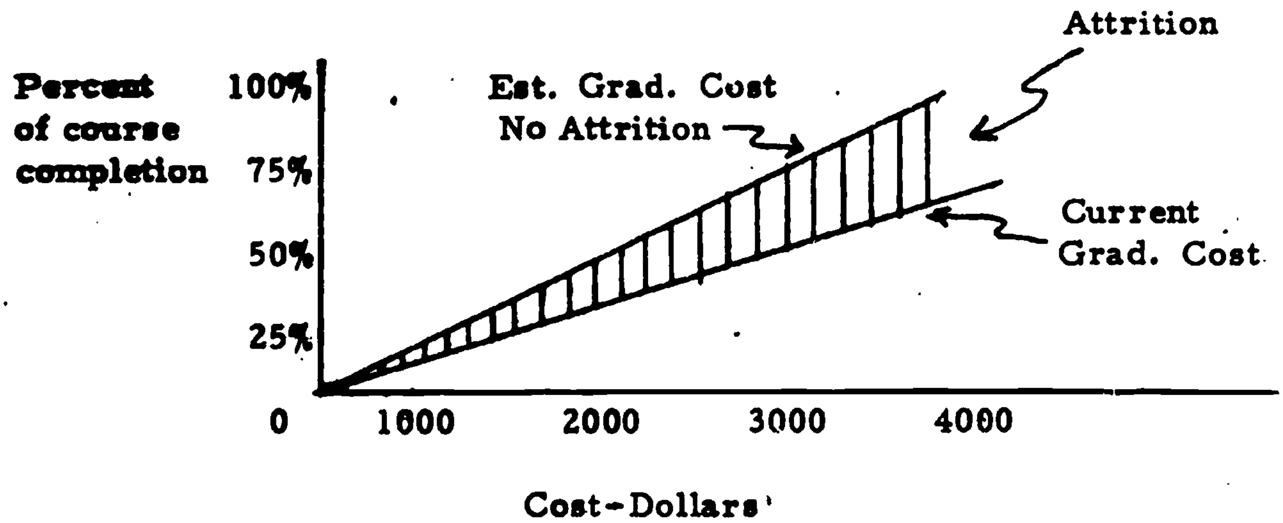


Figure 3-1 Cost of Attrition

If additional funds were available attrition could possibly be decreased with improved instructor training, improved course material, and remedial coaching. At some point there would be little or no gain in efficiency regardless of the resources committed. This is the theoretical area of diminishing returns and maximum effectiveness (Figure 3-1).

Additional effort would most likely produce the most effectiveness if it were invested in CAI program (software) improvement. Consequently, the costs of increasing the effectiveness of the system would be closely related to the costs of improving the presentation of the course materials (software). Again, at some point, committing additional resources would produce little or no increase in course effectiveness.

If these two instructional processes are to be compared on a cost-effective basis, the area of maximum efficiency or diminishing returns must be known so that a relationship between cost and effectiveness may be established. The optimal mixture of cost and effectiveness may be found in some combination of CAI and conventional training. Additional experience and information on the performance and costs of CAI, as well as conventional training, are needed for the completion of a cost-effectiveness analysis of these alternatives.

3.5 IMPLEMENTING COST-EFFECTIVENESS ANALYSIS

3.5.1 Recording Student Training

To implement effectively the methodology described in the Appendices, methods of accurately recording student training time are required. The recorded training time should include the time a student becomes available for instruction up to the time he has completed training and been assigned to other duties. Measurement of this time would represent the total time available for training the student. The burden of cost attached to this time is the cost of producing a graduate. Economical use of this time is essential.

Additional instruction time as a result of attrition and recirculation, the time students spend waiting for classes to form and reassignment, and all other periods of waiting must be recorded.

The cumulative cost of this additional instructional time and the cost of student waiting time are results of the inefficiencies of the training process. Reducing these costs should result in increased cost-effectiveness. The full exploitation of available unique CAI capabilities shows great promise for reducing such costs.

3.5.2 Other Unique CAI Capabilities with Cost-Effective Implications

The cost implications of student selection may be equated to reducing student instructional time and the resulting burden of cost. Early recognition of potential academic failures, remedial branching, individualized instruction, and various other possibilities are potential steps that should ultimately result in reduction of the cost of producing student graduates.

3.5.3 Administrative Tasks

In areas other than the instructional process, the CAI system can perform various tasks which may result in increased administrative and evaluation capabilities and offer the potential of reducing administrative overhead costs. Some of these tasks include scheduling students, keeping student records, compiling reports, and processing data. Additional study of the USASCS administrative system is required before any assessment of these cost savings may be estimated.

3.6 COST COMPARISON SUMMARY AND CONCLUSIONS

The primary thrust of the cost comparisons of this report was to compare two major classifications of cost of CAI and conventional instruction. The comparisons are:

a. CAI program development cost with conventional course development costs (Appendix C)
b. CAI instructional system cost (IBM 1500 Instructional System at USASCS) with conventional instructions cost at USASCS.

An actual cost comparison could not be made between CAI program development costs and conventional course development costs due to a lack of reliable representative cost data.

Theoretical cost estimates of CAI course development cost could be developed from data on man-hours, computer time, and support data. However, these estimates are not presented because these data represent a very limited experience under a developmental learning situation, and the resulting cost estimate could be totally misleading and, further, may not be applicable to CAI course development at USASCS. In addition, conventional course development costs were not available with which to make meaningful comparisons.

The data on CAI course development presented on page 2-2 represents the experience of one short experiment in CAI course development and provides a general indication of effort required. As experience and knowledge is gained, these factors and the attendant cost probably can be reduced substantially.

Tables C-14 to C-17 provide data on the estimated cost of producing course graduates by conventional modes of instruction and CAI for comparative purposes. Unavailability of complete cost data introduces certain

inconsistencies, as discussed in Appendix C. Although these data imperfections are acknowledged, the data are considered accurate enough to provide a basis for some general conclusions. These data show estimated cost of the CAI system graduate for course 26L20 under various reductions of instructional time, depreciation schedules, and usage of the CAI system. The cost per graduate shown in Appendix C (page C-29) indicates that the cost competitiveness of CAI is primarily a function of reduction in instruction time, system utilization, and depreciation. Thus, it is clear that in order for the CAI system to be cost-effective, it must accomplish a reduction in instructional time and be utilized to its full capability.

These are the results of the cost analysis:

- The current economic feasibility of a CAI system at USASCS has been demonstrated
- Although the relative cost-effectiveness of a CAI system vs conventional training at USASCS has not been demonstrated, the costs are not prohibitive and appear reasonable for this stage of a developmental training system
- Conditions under which CAI could become cost-effective have been identified.

SECTION 4

APPLICABILITY OF COMPUTER ASSISTED INSTRUCTION

This portion of the study investigated the applicability of CAI to military training by surveying the equipment and languages available and their uses. and from these developed a model for USASCS.

This study first looked at the development of individualized instruction. Then it surveyed the present status and operation of hardware as well as the wide variety of languages available and under development. It reported the many, varied applications of CAI in universities, non-profit organizations, and private industry. CAI is used to drill and teach, assess learning difficulties, and respond to the student's progress to improve his instruction. Many traditional instructional techniques have been adapted to CAI so that it has taken over some of the responsibilities of the instructor.

On the basis of this survey, a USASCS training model was developed. This includes selection of material to be taught and the amount to be converted to CAI. It also includes the types of hardware and the types, number, and duties of required personnel.

4.1 BACKGROUND

Though the origins of programming and individualizing the instructional process are complex, current methods appear to have been derived from the research of Sidney L. Pressey, B. F. Skinner, and Norman A. Crowder, who are generally considered to have made significant contributions to the development of individualized instruction. Pressey (1926, 1927) observed that a student gained appreciably from seeing the results of an examination immediately. Skinner (1954) suggested the application of reinforcement theory to the learning process. Crowder (1959) suggested that the student's response may best be used as a guide for further direction of the student's activities. The results of the above research were implemented on electromechanical training devices and finally in Computer Assisted Instructional systems (CAI).

Electromechanical training devices, developed primarily for the purpose of training armed service personnel, preceded the development of CAI systems. Stolurow (1961) suggests that three training devices may be considered to have contributed directly to the development of CAI. Pask (1957) developed an Interactive Decision Making Assembly (IDMA), adaptable to learner needs, to train radar operators. Rheem Manufacturing Corporation developed Didak 1001 to teach typewriter and keypunch operations; a computer-like device controlled the rate of presentation and problem difficulty. Then Pask developed the Solartron Automatic Teacher (SAKI) to train operators to punch information in cards.

The difficulty with electromechanical training devices was the total dedication of a single machine to a single learner for a single training objective. In the late 1950's, a research team at IBM modified a digital computer for the purpose of implementing a new multi-purpose, multi-student training device (Rath et al 1959). This was the forerunner of a series of similar developments.

Bitzer et al (1962) developed a Programmed Logic for Automatic Teaching Operations (PLATO). This teaching system incorporated a closed-circuit television system, student control panel, and the University of Illinois' ILLIAC computer. PLATO could serve two students simultaneously but on an individual basis. Uttal (1962) at IBM used an IBM 1410 data processing system to provide Computer Assisted Instruction to forty individual students simultaneously. Coulson (1962a) implemented a Computer-based Laboratory for Automated School Systems (CLASS) on a Bendix G-15 computer system. Swets et al (1965) used a Digital Equipment Corporation PDP-1 to implement an early version of a conversional system. Stolurow (1964b) implemented a System for Organizing Content to Review and Teach Educational Subjects (SOCRATES) on an IBM 1620 computer. Suppes (1965b) employed a modified PDP-1 with sixteen student stations in order to research learning models. Shuford (1965) also used a PDP-1 but for the purpose of studying testing strategies.

In 1965, IBM announced the first commercially available software package which could be used to implement CAI on a standard data processing system.

4.2 CAI SYSTEMS REVIEW

Every CAI System has three primary components. They are the hardware (or computer circuitry), the software (or computer programs, including the educational material), and the personnel needed to implement and operate the system. Personnel requirements will be discussed with the USASCS training model.

4.2.1 Hardware

There are two general types of hardware. The first is the totally dedicated type. The circuitry is designed to run only one program at a time at maximum efficiency. The second type of hardware is the multi-processing configuration which permits the simultaneous execution of two or more programs. Multi-processing systems which require more circuitry and are more expensive are not commercially available at the present time. Though they may cost more, they can lower costs by simultaneously performing other data processing tasks. Dedicated and multi-processing systems have common basic components.

a. The central processing unit contains the control, logic, and arithmetic circuitry of the computer. It is this circuitry which directs the sequence of operations, interprets the coded instructions, and initiates the proper signals to other circuits to execute the instructions. Generally speaking, the size of this component is affected by the decision to dedicate or multi-process.

b. Large volume storage devices are needed to contain educational material and student data. Ideally, these devices consist of record units which are interchangeable magnetic disks or tapes. The system may be limited in the number of record units which can be run at any one time, but their interchangeability assures that the total amount of educational material is not limited. At least one data storage unit must be devoted to recording each interaction between the student and machine. This record, when summarized, provides the educator with a data base which may be analyzed to evaluate the materials and improve educational effectiveness (Betts, 1967a).

c. A communications control unit must be included to handle messages. This device keeps the interaction between student A

and the machine separated from the interaction between student B and the machine.

d. The input-output devices enable man and machine to communicate. Minimum requirements include a card read/punch device for card input and output, a printer for listing the educational material and data analyses, a machine operator's console, and the student stations.

4.2.2 Programming System.

The CAI software package should include the CAI operating system—for example, Coursewriter II on the IBM 1500 Instructional System—a set of utility programs, and a set of data analysis programs.

The utility programs enable the operator to copy, print, or otherwise manipulate the information stored in the system. The data analysis programs facilitate the statistical analysis of student records and other relevant information.

CAI language characteristics have been reviewed by Dick (1965), Zinn (1965, 1967), Hickey and Newton (1967), and Hansen (1966b). A CAI language must be effective, efficient, and reliable. The effectiveness of the system is measured by the ability of the system to respond to a variety of instructional strategies and research tasks. The efficiency of the system depends upon the ease with which a course unit can be programmed and the amount of work necessary to execute the instructional activities. Reliability is the rapid detection and correction of errors. It is imperative that the system be capable of indicating non-executable programs prior to student use of the training system.

There are five basic modes of operation which the CAI language should be capable of executing.

a. <u>Proctor</u>: Its primary function is absolute machine control. This mode is generally accessible through an authority system which restricts its use to machine operators.

b. <u>Monitor:</u> The primary purpose is system status reporting. Being accessible through a different authority system, this mode is reserved for service personnel responsible for scheduling and logistics support.

c. Author: This mode permits the construction and revision of course material. Access is limited to a specific storage area (of course unit) reserved for that material.

d. Student: This mode permits the teaching of the course material as it is intended to be used in the training system. The mode is individually accessible by each student assigned to the course. It should also be accessible from the author mode for the purpose of initially testing the educational program.

e. Computation: This mode enables the user to work with the computational capability of the computer system. It should be accessible to the four other modes listed above in a manner which does not interrupt the normal activity of that mode.

Hansen (1966b) has prepared a comprehensive listing of CAI languages currently in use. Many of these languages are part of larger, more complex general purpose languages. This fact should be considered in evaluating the efficiency of the language. Another important language consideration is its ability to act upon the student's responses. In scoring responses, the program must differentiate between legitimate content errors and correct answers entered in the wrong form. Wodtke et al (1965) reported significant relationship between the two types of errors within a CAI course. This relationship showed that the student typed in the correct answer in the wrong form, tried the same answer once or twice more for good measure, and then discarded his original correct answer for an incorrect response, thus making a content error. This program can be partially avoided with a CRT device with light pen. But light pen capabilities imply multiple-choice type items, which are difficult to write and which may not be relevant to the desired terminal performance objectives.

CATO is a CAI language developed for the PLATO System at the Coordinated Science Laboratory, University of Illinois (Bitzer et al, 1966). CATO is a modified FORTRAN language in which the programmer has great flexibility for the preparation of three levels of basic program writing: tutorial, inquiry, and simulation.

The Coursewriter I language (Maher, 1964) was constructed primarily for the use of subject-matter writers rather than the technical person involved in computer programming. Coursewriter I provides power and flexibility for developing various pedagogical techniques. Its most important feature is the provision for revising instructional material easily and rapidly. It can also analyze partial answers (e.g., key letters or key words).

The Coursewriter II Language used with the IBM 1500 Instructional System (IBM, 1966) provides a greater opportunity to record the instructional history of a learner. The most important feature of this language is its provision for macros which standardize the logic and require the author to insert only the informational portions of the subject matter. Coursewriter II also provides for a much better control over the timing of the instructional events. Like other numerically oriented languages, it provides mathematical algorithmic translator or MAT (Iverson, 1962) which allows the author and student to solve mathematical equations.

Two languages are in the process of being developed by Bolt, Beranek and Newman. The first is TELCOMP, which is a numerical oriented programming language. The second is MENTOR, which is part of a more generalized LISP language (McCarthy et al 1965). These list processing languages, LISP and MENTOR, provide for great power and versatility in handling natural language statements. For example, a conventional English declarative sentence may be entered and logical operators connected to it so that decisions can be based on the user's progress.

Basic is a CAI language developed at Dartmouth College by Kemeny and Kurtz (1966). Equivalent to TELCOMP and MAT, it solves mathematical problems with a simple set of variable codes.

System Development Corporation is developing two languages. The first is a time-sharing language which implements the CLASS facility cited previously. Problem oriented, it distinguishes between the logic of instructional codes and control statements. A second language called PLANIT, or programmed language for interactive teaching, and being developed by Feingold (1966), provides for both instructional activities and numerical analysis computation. The language has six basic instructional codes; type, problem, question, multiple choice, decision, and copy. The command "Type" allows an author to quickly insert instructional materials into the CAI system. The system also allows a learner to both calculate and answer problems.

The THOR time-sharing language system developed at Stanford (Brian, 1966) has all of the features found in variable oriented CAI languages. Subsets of the THOR language provide mathematical drill problems or tutoring. A valuable feature of the THOR language is a real-time debugging aid called RAID (Stygar, 1965).

Using the SOCRATES System at the University of Illinois, Stolurow and Lippert (1966) have developed a language, AUTHOR, that prepares course materials under computer control. AUTHOR allows for natural language text construction.

Engvold and Hughes (1967) of IBM have recently published a report on ABAC II, which is a basic coursewriter written in FORTRAN.

4.2.3 Applications

The majority of CAI activities are centered in major universities, non-profit organizations and private industry. They used off-the-shelf CAI systems modified in many cases to fit unique needs. A few schools use CAI to teach regularly. Many public and private organizations are experimenting with a variety of subjects. Approximately 225 courses exist in various stages of development to teach psychology, statistics, economics, public administration, languages, mathematics, chemistry, engineering, medical science, business, and other subjects.

Florida State University at Tallahassee has a multimedia course taught for credit by CAI (Hansen and Dick, 1967). Physics is taught for three credits on an IBM 1500 Instructional System using a cathode ray tube, a tape recorder, short concept films, full length films, video taped lectures, and a typewriter.

Reading and arithmetic are taught to disadvantaged elementary school children in the Brentwood School near Palo Alto, California. Material developed by Patrick Suppes (1965a) of Stanford is presented on the IBM 1500 Instructional System by a tape recording, and students respond with the light pen.

Pennsylvania State University at University Park has developed, under Harold Mitzel (1967), courses in audiology, introductory management accounting, engineering economics, and modern mathematics. Content was first teleprocessed from an IBM 7010-1440 at the T. J. Watson Research Center at Yorktown Heights; then, later it was presented by an IBM 1410-1440 computer at the University's Computation Center. The instruction presented by a random access slide projector, tape recorder, and typewriter has been tested on a limited number of students (Mitzel and Wodtke, 1965). Penn State presently has a contract with IBM to develop for their projected IBM 1500 IS an Audiometer Trainer Terminal.

This unit is to be outwardly representative of typical audiometers with labeled switches, dials, etc. Internal instrumentation (e.g., points, encoders, scanner, and code matrix) would allow the unit to transmit to the CAI system the student's setting of the external audiometer controls, which the system would interpret as a response.

The University of Texas at Austin is using an IBM 1440 teleprocessed to fourteen 1050 terminals. Its CAI Laboratory, under C. Victor Bunderson, installed the first production model IBM 1500 Instructional System with eight terminals. Laboratory personnel have developed instruction in chemistry and mathematics (prerequisite to chemistry) with members of these two departments. They have developed procedures for writing, coding, and preparing materials (Holtzman et al, 1967).

IBM Corporation has trained customer engineers by teleprocessing instruction from Poughkeepsie to Philadelphia, Los Angeles, San Francisco, and Washington, D. C. An IBM 1440 is used to teach System/360 and remote maintenance (Schwartz and Haskell, 1966).

System Development Corporation, Santa Monica, California, uses a Philco 2000, having a random access projector, cathode ray tube, light pen and buttons, and Rand Tablet. The experimental Computer-Based Laboratory for Automated School Systems (CLASS), under John Coulson, has 20 teaching and two teacher stations (Coulson, 1962b).

The Edison Responsive Environment, developed by O. K. Moore, teaches young children to read. Students learn to associate letters by hearing them on tape, seeing them displayed, and typing them. They respond by typing and recording letters, later words and sentences (O. K. Moore, 1963). There are ten such 'talking' typewriters in use by Project Breakthrough at the Westinghouse Vocational Center and more than 100 prekindergarten children are currently participating in the program.

The Coordinated Science laboratory under Donald Bitzer uses a CDC 1604, which has ten terminals, slide projector and display devices (Bitzer et al, 1966). Lawrence Stolurow (now of Harvard) has developed a System for Organizing Contents to Review and Teach Education Subjects (SOCRATES). Using

an IBM 1620/1710, he has researched psychological models of instruction and requirements for effective teaching systems (Stolurow, 1965a, b).

Richard Wing of the Northern Westchester Board of Cooperative Education Services has developed three economics games for elementary school children. He used a 1052 terminal teleprocessed to an IBM 7090 computer in Poughkeepsie and an IBM 1401. In the Sumerian Game, sixth graders make decisions about allocating agricultural resources based on information presented by the computer (Wing, 1964).

Philco-Ford Corporation has announced an automated system for education which combines the advantages of electronic instruction with two-way dialogue between the student and the instructional program. The school district of Philadelphia authorized a $1.3 million contract with Philco in which the company will provide the school system with a Philco 2000 computer, four Philco 102 data processors, and 32 consoles. The Philco 2000 computer will interface with the smaller 102's, which will be installed at four schools. Each smaller data processor can be operated independently and can serve student terminals at each location. The student terminal consists of keyboard and a CRT with instructions presented on the tube, through a speaker at the terminal, or both. The student responds using a keyboard or an electronic stylus (Automated Education Letter, 1967).

Other instruction techniques are being developed at the University of California campuses at Irvine and Santa Barbara, Dartmouth College, Massachusetts Institute of Technology, Electronics Systems Division at Hanscom Air Force Base in Massachusetts, Harvard, Stanford, University of Pittsburgh, Westinghouse, and Bolt, Beranek, and Newman. The interested reader should consult literature reviews by Gentile, (1967) Hansen (1966), Hickey and Newton (1967), and Zinn (1967).

An interest in CAI within the military has been expressed by officials of the Army, Navy and Air Force. Besides the USCONARC CAI Project, the following projects are reported as currently active (ENTELEK, 1968):

The Army has:

a. CAE at the Infantry School (CAETIS)

b. Computer Supported Supply Instruction at the Quartermaster School (Fort Lee)

c. Project Impact (HumRRO)

d. USCONARC Educational System (CONEDS)

The Navy has:

a. Navy CAI Program for Electronics Training, San Diego

b. CAE at the U.S. Naval Academy

c. ONR Research in CAI (includes the exchange conducted by ENTELEK)

d. Naval Air Technical Training Command CAI Project

e. BuMed Computer Assisted Instruction Project

f. CAI in Trouble Shooting and Maintenance

The Air Force has:

a. Technology of CAI - Behavioral Sciences Laboratory (BSL)

b. Research toward CAI with Natural Language - BSL

c. Phase II Program (CAI Subsystem for Base Management System) - Electronic Systems Division (ESD)

d. CAI Needs for Air University - BSL

4.2.4 Commercially Available Systems

At the present time, there are apparently three hardware systems designed especially for CAI applications: Philco-Ford Student Audio Visual Interface System (SAVI), Philco-Ford CLASS System, and IBM 1500 Instructional System. A fourth system being developed by RCA has the preliminary designation, 1600 Instructional System.

o Philco-Ford SAVI

Early in 1967, Philco-Ford announced the availability of a new student station (SAVI) which could be used with the Philco 2000 series

computer systems. This system should not be confused with the CLASS system. The Student Audio Visual Interface system may handle as many as thirty-two student stations on an individual basis.

- The Philco-Ford CLASS System has been discussed above under the development work by Coulson et al (pages 4-8).

- IBM 1500 Instructional System

In 1966, IBM announced the first commercially available instructional system developed jointly by industrial and educational communities. This was the IBM 1500 Instructional System.

The IBM 1500 IS hardware includes instructional stations, disk storage units, a station control, an IBM 1130 processor with card reader/punch, and a line printer. The processing unit and station control act as an intermediary between the student and the course material stored in the disk storage units. Presently, a maximum of 32 instructional stations may interact with the operating system simultaneously. The instructional station is modular and consists of the following display and response devices: cathode ray tube instructional display and keyboard, instructional display light pen, random access image projector, and typewriter.

On October 6, 1967, RCA announced the development of a series of small binary computers to be used in computer aided instruction. The target date for initial production is mid-1968 and, hence, design details are not yet available.

4.3 INSTRUCTIONAL TECHNIQUES IN CAI

Those instructional techniques in basic electronics training which may be effectively implemented through the use of computer-assisted instruction (CAI) fall into three general categories:

a. Practices requiring low-level demands on the time of the instructor (e.g., drill and practice)
b. Practices directly and indirectly related to the counseling of students (e.g., assessment of learning difficulties)
c. Practices associated with reinforcement and improvement of instruction (e.g., preparation of supplementary aids).

Each of these categories will be treated individually.

4.3.1 Practices Requiring Low-level Time Demands

Those practices which require low-level demands on the instructor's time include:

a. Classroom supervision to maintain student participation
b. Teaching of facts and skills
c. Drill and practice
d. Grading of written assignments
e. Administration and grading of tests
f. Supervision of laboratory exercises

4.3.2 Classroom Supervision

The purpose of classroom supervision is to obtain information concerning the student's progress and to evaluate that information in order to decide on the most appropriate sequence of activities relevant to the realization of the training goal. Supervision entails two tasks, generation of data concerning the student's progress and evaluation of that data. Discussion of the evaluation process will be found in the section related to counseling. This section covers problems of generating data from the student's performance.

To obtain data on the student's progress requires some participation on the part of the student. Student participation in the instructional environment, in itself, may be a significant factor in improving learning.

Kurpiewski (1958) compared the relative effectiveness of four methods of lecturing on direct current electricity. The results showed that student participation during the learning process creates a more effective teaching approach. In a study designed to identify the significant factor in programmed instruction, G. L. Gropper (1967) found that structuring the educational material was not sufficient. In his conclusions, Gropper states:

> It seems clear, on the evidence produced here and elsewhere, that the success of programmed instruction depends both on effective design of the stimulus and on appropriate response practice... Thus, from this point of view, selecting only one of two key features of programmed instruction is not likely to produce desired results.

A CAI system alters the supervisory role of the instructor significantly by requiring each student to make some response in order to proceed with the instructional activity. These responses are the input data which are used to evaluate the student's progress.

4.3.3 Teaching of Facts and Skills

An individualized tutorial approach to student-teacher interactions has been suggested in the literature to be the fundamental instructional model (Skinner, 1958; Stolurow, 1964 b; and Thorndike, 1932). Tutorial CAI systems may be employed to provide the desired interaction.

A tutorial CAI system for material presentation takes over the main responsibility for developing skills in the use of a given concept. One of the most consistent findings with CAI tutorial applications is marked savings in instructional time with no loss in post-instructional achievement performance. Grubb and Selfridge (1963) taught descriptive statistics to a small number of college students via CAI. This CAI presentation was compared with college students' taking instruction from the conventional lectures and via programmed text. Those students working under CAI completed the course material in one-tenth the time and performed almost twice as well on the final achievement test as did the other two groups. Schurdak (1967) taught forty-eight college students a portion of a course in Fortran programming. When equated for mental ability, the CAI students saved approximately

ten percent of the work time in completing their course as opposed to students using a standard text or program text. They performed approximately ten percent better on the final criterion test. Goodman (1965) reported instruction of 3,000 airline ticket agents via CAI. In comparison with the control group of ticket agents receiving conventional instruction, CAI reduced the training time by one-half, and final test grades were approximately five percent better for the CAI students.

Dialogue CAI systems allow the student to conduct a genuine dialogue with the computer in a manner which simulates a tutorial session. Weisenbaum (1966) described a dialogue system, ELIZA, based on the Rogerian psychological interview. In the ELIZA system, the computer considers messages generated by the student's typewriter and replies to the user through the same typewriter. When engaged in conversation with ELIZA, the user types in a statement or set of statements in natural English.

The ELIZA system then analyzes these statements and generates a response derived from the original statement. Feurzeig (1964) reports a dialogue based on the SOCRATIC tutorial system. In the SOCRATIC system, the student is given a list of words which specify the vocabulary for the problem. He sits at a typewriter console and is immediately presented with a problem. He is subsequently engaged in a conversation with the computer as he solves the problem.

4.3.4 Drill and Practice

One of the objectives of the USCONARC TDP is to investigate the feasibility of preparing students of lower aptitudes for employment in the electronics skills. Part of this task would be to upgrade these students in basic skills such as reading and arithmetic.

There is abundant evidence from recent pedagogical and psychological studies that students need a great deal of practice in arithmetic skills before a reasonable level of mastery is obtained. One of the natural applications for CAI is the provision for continuing practice and evaluation of the learner who needs extensive training. In the provision for repeating those items which are presenting difficulty to the learner, Suppes et al (1965) reported that inexperienced learners show progressive improvement in learning a series of arithmetic concepts when simple reinforcement procedures are involved in indicating incorrect responses and repeating incorrect items immediately.

Hansen (1966) reported learning curves which described daily spelling drills presented by a CAI system. Those drills indicated a significant improvement in spelling competence.

The important difference between this drill system and the traditional teaching method is that with CAI the instructor has the capability of meeting the needs of each student. With this capability, each student can receive problems which will challenge him whereas, with traditional textbook assignments, no differentiation can be made.

4.3.5 Grading of Written Assignments

When one considers the grading of written assignments, one may immediately recognize the role of a CAI system - the student is simply required to complete his assignment at the student station. The end result is a problem session which is not different from the drill and practice application mentioned above.

The data base provided by the CAI system provides the instructor with a sequential record of the student-machine interaction which permits an evaluation of the students progress (Betts, 1967a).

4.3.6 Administration and Grading of Tests

Zinn (1965) and Shuford (1965) proposed that CAI provide the capability for a type of testing not ordinarily available in the conventional paper and pencil system. The most important feature of CAI in this application is the real-time analysis and decision-making capability of the system.

This real-time analysis enables the usage of a specified data base to determine the exact sequence of test items to be presented. Mager and Clark (1963) recommended that branching of a learner systematically through a test could maximize both the desired level of difficulty and coverage of test content.

Hansen and Dick (1967) reported preliminary results of a sequential testing study involving college level chemistry and physics. The sequential test design employed in this study is similar to that suggested by Rajartanam et al (1964). The primary advantage in the Hansen and Dick study is the use of the CAI system.

It is clear that the educators and psychologists desire a testing system which combines the objectivity of standardized test instruments with the advantages of individual interview techniques. The development of devices which enable computer-controlled simulation of such an interview has significantly impacted the field of test and evaluation. Computer Assisted Instruction systems operating in a testing environment represent a quick, efficient, and economical means of large scale test administration. CAI systems have been shown by Hansen and Dick (1967) to be capable of analyzing the student's state, selecting a decision rule, executing the rule, and providing the next appropriate item. Figure 4.1 shows a generalized sample test structure. The objective of this design is to take a student of given or predicted achievement and permit him to work his way through the test. Upon completion, the student will have demonstrated a true or nearly true level of aptitude and ability. For example, an A student would start with an item which only 20% of the population would pass. If he passed the item, he would then take an item which only 10% would pass. On the other hand, if he missed the first item, he would take a less difficult item. This Markov process would enable the student to demonstrate his true comprehension of the material.

4.3.7 Supervision of Laboratory Activities

Concerning the supervision of laboratory activities, Hansen et al (1967) reported the development of a CAI system designed to monitor junior high school science experiments. In reporting on a use of CAI in a simulation of the chemistry laboratory, Hirsch and Montcreiff (1965) in the study of a model which simulates analytical procedures report that simulated environments provide the facilities for random response and require the student to make decisions in response to the environmental situation presented, rather than to simply recognize a correct response or recall a memorized procedure.

In each of the above examples, the use of a CAI system has provided a set of data from the student by requiring him to be an active participant in the learning process. Three things have been accomplished:

a. data banks, containing several kinds of information concerning the student, have been created which are available for the evaluation of the student's progress

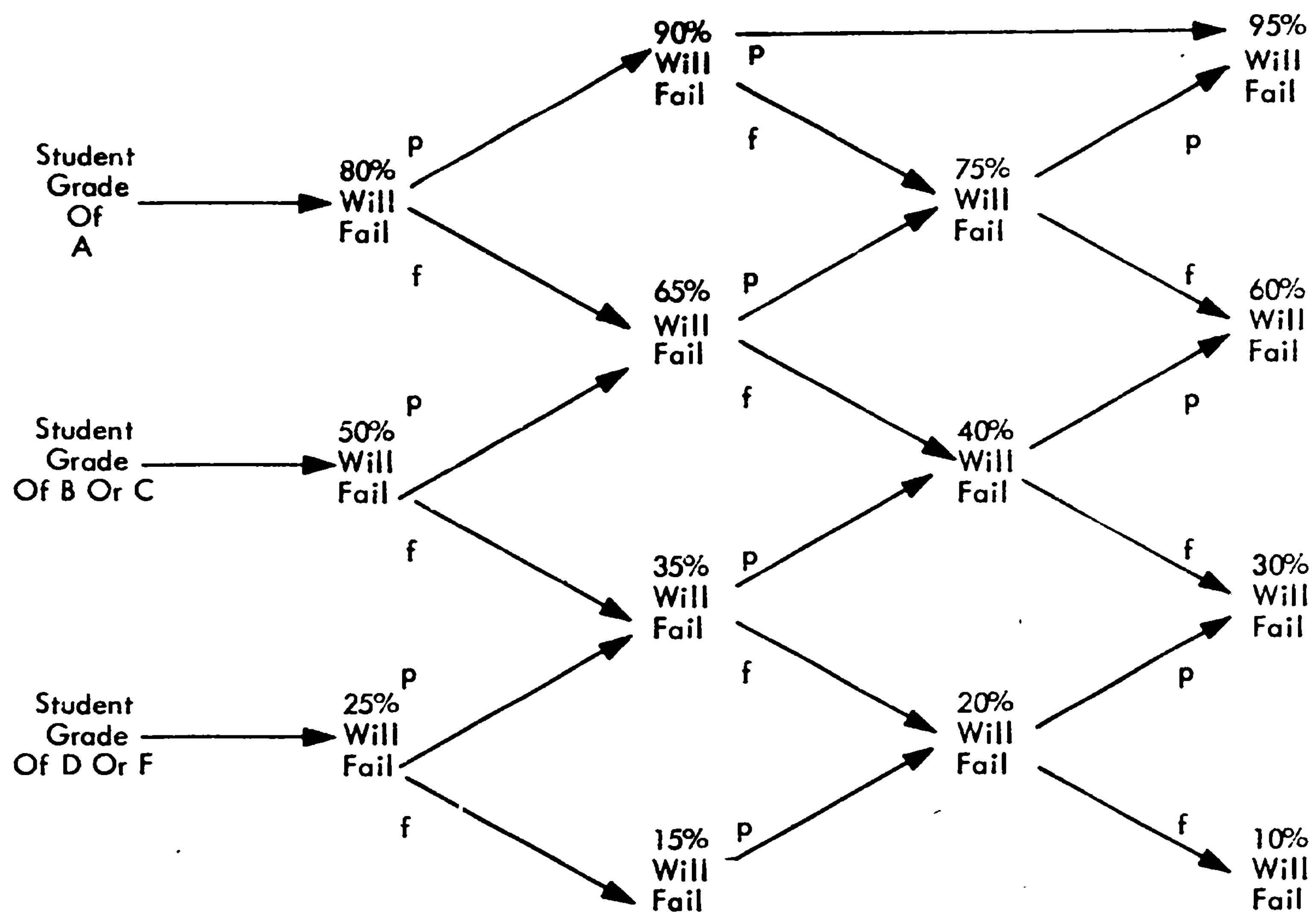


Figure 4-1. Sequential Test Design

b. the instructional process has been improved by including student participation

c. the instructor has been relieved of supervisory duties.

4.3.8 Practices Related to Counseling

In addition to those practices requiring low-level demands on the instructor's time, several studies have investigated those practices related to the counseling of students. The instructor spends a significant portion of his time counseling. When a class fails to understand a lesson or a student cannot perform a practical exercise, the instructor must determine the reason for the failure and advise the class or the student on how to overcome the problem, that is, decide on the most appropriate sequence of activities.

The counseling process entails an evaluation of the data on the student's progress. Previous sections have discussed how these data can be obtained in the CAI environment. The studies which follow give examples of different types of evaluation.

Cogswell et al (1967) reported the investigation of a computer oriented counseling system. This sytem was designed to automate an educational interview which reviews student progress, collects student comments, reacts to student plans, and helps the student organize his schedule.

A similar system has been reported by Tiedeman (1967). His information system, for vocational decisions, gives the student assistance in making his own career choices by giving him more complete background information.

Maruyama et al (1966) reported on the alteration of CAI dialogue systems for the purpose of supplementing industrial counseling. As in the ELIZA system mentioned above, Maruyama's system conducts a Rogerian dialogue with the patient-user. The purpose of this on-going investigation is to demonstrate the feasibility of conducting industrial counseling via machine while maintaining the necessary emotional rapport between the programmer and user and while maintaining the capability for effective use of relevant material.

Concerning practices indirectly related to the counseling of students, counseling is greatly facilitated by that data base because of the data collection facility of a CAI system. In addition, because of the other capabilities of the CAI system, the CAI system frees the instructor to spend more time with the individual students (especially those students who are having difficulty with the material).

4.3.9 Practices Associated with Improvement of Instruction

Those practices involving reinforcement and improvement of instruction also depend heavily on the data generated from the CAI system. For example, Jettsson and Walmark (1965) reported the programming of a text book. In this study, the authors prepared a series of programmed instruction booklets for use as supplemental aids to a text book. Although this study relied upon programmed instruction techniques, the obvious generalization is the application of CAI systems.

Print routines may be designed to use the student response file as a guide for the preparation of summaries and other supplemental aids.

Feldman (1967) at the University of California at Irvine suggested the need for hard-copy summaries for CAI students. The Irvine project apparently uses special tear-away forms designed to fit conveniently in a three-ring binder. The preparation of supplementary aids via CAI has considerable advantages in cost and flexibility over the conventional method of editing the traditional text.

Standard educational measurement and evaluation techniques which are appropriate for the development and revision of instructional materials exist, today, in th teacher training literature (Thorndike and Hagen 1961). Such techniques as test construction, item writing, item statistics, and item revision may be readily adjusted for CAI application (Betts, 1966).

Measurement data for accurate evaluation of instructional materials is readily available for all students taking part in the CAI-oriented environment. In addition to providing the standard item analysis data for the evaluation of a particular frame or sequence of frames, the data system also provides the capability of investigating

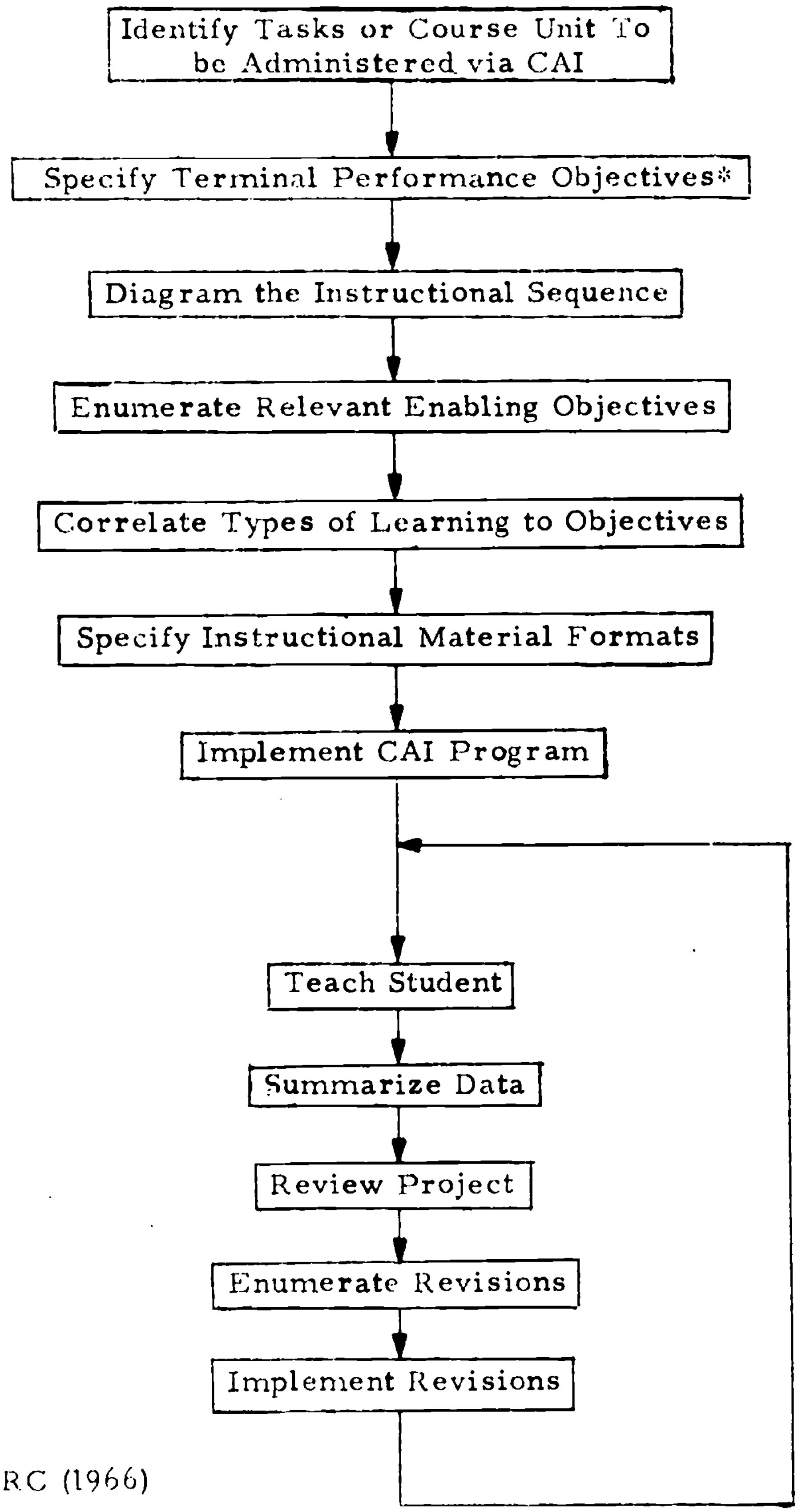
learning protocols of new techniques and strategies in the teaching of a particular subject (Betts, 1967a). The use of the student response data file enables the development of adaptive instructional materials for various teaching strategies, i.e., materials which can be flexible, depending upon the personal profile of a given student and materials which may legitimately be compared to other pedagogical techniques.

Zinn (1967) has enumerated several projects which address the potential of computer generated materials, that is, educational materials automatically structured and produced by data processing systems.

An educational material development procedure which depends on the standard measurement techniques is shown in Table 4-1.

TABLE 4-1

THE DEVELOPMENT OF EDUCATIONAL MATERIALS FOR USE IN COMPUTER-ASSISTED INSTRUCTIONAL SYSTEM



*USCONARC (1966)

4.4 THE USASCS TRAINING MODEL

The approach used to identify the USASCS CAI requirements to support the implementation of Stage I of the USCONARC TDP was to define the relationships between the subject matter covered and the instructional methodologies used in the first seven weeks of basic electronics training currently given at the USASCS and approximately 40 hours of New Equipment Training provided by the US Army Electronics Command (USAECOM). Once these relationships were established, a comparison of the conventional methodologies and CAI methods could be made to ascertain what subject material in the two training situations was most adaptable to CAI presentation.

4.4.1 Basic Electronics Training

The first seven weeks of Microwave Radio Equipment Repair Course (26L20) was selected as representative of approximately 204 hours of Basic Electronics training. During this instructional period, six major topics are covered: Direct Current Fundamentals (51 Hours), Amplifiers (30 Hours), Receivers (30 Hours), CW Transmitters (30 Hours), and AM Transmitters (30 Hours). The current Signal School week consists of 40 periods* except for the first week, which begins on a Tuesday and consists of 28 periods.

The modified Program of Instruction (POI) covering these seven weeks uses six instructional methods: television presentations, conferences, demonstrations, practical exercises, programmed instruction, and tests. An item called miscellaneous was included as part of instructional time and accounts for instructor and student time spent on roll call, preparation for tests, moving to new classrooms, cleanup, and television news.

Table 4-2 from the POI indicates the length of time each instructional method is used for each of the seven weeks. Without the 10 hours allotted to miscellaneous, the actual instructional time totals 192 hours and 35 minutes. The combination of television, demonstrations, programmed instruction, conferences, and tests accounts for approximately 80% of this actual time and practical exercise accounts for about 20% of this time.

*One period equals 45 minutes of instruction.

Table 4-2

SUMMARY OF INSTRUCTIONAL TIME
BY INSTRUCTIONAL METHODOLOGY

INSTRUCTIONAL METHOD

	Misc.	TV	Demo	PI	Conf	PE	Test	Instruction Hrs.
D.C. Fund Week I	2:00	9:09		2:42	2:00	5:09	0	**21 hrs.**
D.C. Fund Week II	2:10	9·14		4:32	4:24	6:00	3:50	**30 hrs. 10 min.**
A.C.	:50	10:24		1:15	4:52	8:44	3:55	**30 hrs. 20 min.**
Amplifiers	1:35	11:13			5:06	8:56	3:30	**30 hrs. 20 min.**
Receivers	1:00	:15	3:35		18:00	5:50	1:40	**30 hrs. 20 min.**
CW Transmitters	1:15		2:45		20:50	4:15	1:00	**30 hrs. 5 min.**
AM Transmitters	1:10	:25	3:00		16:20	5:10	4:35	**30 hrs. 20 min.**
Total Time	10:00	40:40	9:20	8:29	71:32	44:04	18:30	**202 hrs. 35 min.**
Percentage of Time	4.9%	20.0%	4.6%	4.1%	35.3%	21.7%	9.1%	100%

Key:

Misc - Miscellaneous
TV - Television
Demo - Demonstration
PI - Programmed Instruction
Conf - Conference
PE - Practical Exercise

The six instructional methods are standard techniques used at all USCONARC schools, with minor exceptions. One of the exceptions is the use of television which is employed, when appropriate, by the Signal School as a substitute for the conference or lecture method. In these cases, video tapes are made of an instructor presenting subject matter to students in an actual classroom situation. These tapes are then played to subsequent classes in the presence of an instructor who monitors the class and answers student questions at the end of the television presentation. Another exception is that programmed texts are used primarily to supplement television presentations and conferences but are also used as reference material for out-of class assignments.

When the subject matter covered by each of the instructional methods was examined, certain relationships were found which can be used to determine the adaptability of this material to CAI. In general, the subject matter is basic and requires the instructor to impart to the student a considerable amount of general facts relating to a variety of topics over a short period of time. In addition, basic skills have to be learned and concepts understood so that instruction is often repetitious, and considerable time is spent on drill and practice exercises covering these points. The instruction also has to give the student the opportunity to apply his newly acquired skill to meet course performance objectives. Finally, a standard has to be set to evaluate the quality of instruction and the student's achievement.

Demonstr ns, television presentations, and conferences are the main metho sed to impart general information to the student. In these sessions the instructor usually covers important points and then asks questions to reinforce the students' understanding. Drill with programmed text supplements the other three methods of instruction. Practical exercise instruction allows the student to apply his newly acquired skill by requiring him to solve a problem or perform a performance objective task. Daily and weekly examinations given during the seven weeks provide information relative to the quality of instruction and grade the students' progress against course objectives.

4.4.2 New Equipment Training

Based on the recommendation of the New Equipment Assistance Element of the Maintenance Engineering Directorate, USAECOM, the course on Radio Set AN/GRC-103 was selected as representative of new equipment training. The purpose of this course is to train experienced personnel to inspect, test, and perform general maintenance on Radio Set AN/GRC-103. The course consists of 64 fifty-minute periods or approximately 53 hours of instruction (Table 4-3).

Twenty-one and one-half hours are allotted to lecture conferences, twenty-five to practical exercise, and six and one half hours to examinations, of which one hour is a pretest.

Table 4-3

SUMMARY OF INSTRUCTIONAL TIME
BY INSTRUCTIONAL METHODOLOGY
(AN/GRC - 103)

COURSE	INSTRUCTIONAL METHOD			
Radio Set	Lecture/Conference	PE	Tests	Total Hours
AN/GRC-103	21:30	25:00	6:30	53:00

PE = practical exercise

The course, conducted by travelling teams of instructors, requires that an actual operating model of the AN/GRC-103 or training simulator be available at the training location. Before any instruction is given, each student takes a pretest to determine his knowledge of transistors. Those students who have little transistor experience, as indicated by their grade on the pretest, are given special attention and remedial assignments.

Of the 21-1/2 lecture/conference hours, approximately 6 are straight lectures and 15-1/2 require a student workbook. Using this workbook, the student is led through drill exercises in block diagram and schematic analysis.

Most of the 25 hours allotted to practical exercise instruction requires the student, directed by a team instructor, to test equipment and solve troubleshooting problems directly on one of the AN/GRC-103 modules. The examinations given are primarily paper and pencil problem-solving exercises.

4.4.3 Subject Matter Adaptable to CAI Methodologies

The above review established the relationships between the subject matter taught and the instructional methods used in Basic Electronics and New Equipment Training. Based on knowledge and experience in the use of

CAI systems, it is generally concluded that material can be developed for CAI presentation which is now being taught by the following standard instructional methods: television presentations, conference/lecture, demonstrations, programmed instruction, and examinations. The applicable CAI methodology is:

a. Presentation of general and specific information which requires a correct response to demonstrate knowledge and understanding of the subject matter

b. Drill, practice, and review for acquisition and reinforcement of terminology, associations, concepts, and nomenclature

c. Administration and scoring of examinations

d. Problem-solving exercises which allow a student to apply acquired knowledge to solve conceptual problems requiring integration of basic principles and information.

In the case of practical exercise instruction, each exercise would have to be considered individually as to its adaptability to CAI. The main considerations are type, size, and cost of the devices required in performing a task and the method by which successful performance is measured. The use of off-line, small, inexpensive exercise boards and test equipment used in conjunction with CAI during this study did demonstrate how the system could direct, monitor, and measure functional training. Some consideration should also be given to developing CAI training simulators which would be connected on-line to a CAI system. These devices, under computer assistance, would simulate the operation of actual equipment. They would contain sufficient instrumentation to measure and encode student actions under a variety of preselected situations. In these situations, the student's step-by-step performance could be monitored and measured.

Based on this comparison of conventional and CAI methodologies, it is estimated that of the total instructional time allotted to each of these two courses 150-160 hours (80%) of Basic Electronics and 30-40 hours (50-70%) of New Equipment Training are adaptable to CAI presentation.

4.5 USASCS CAI SYSTEM CHARACTERISTICS

The flowchart (Figure 4-2) describes the general characteristics of a CAI system which will provide the USASCS with the capability to support the implementation of Stage I of the USCONARC TDP. Specifically,

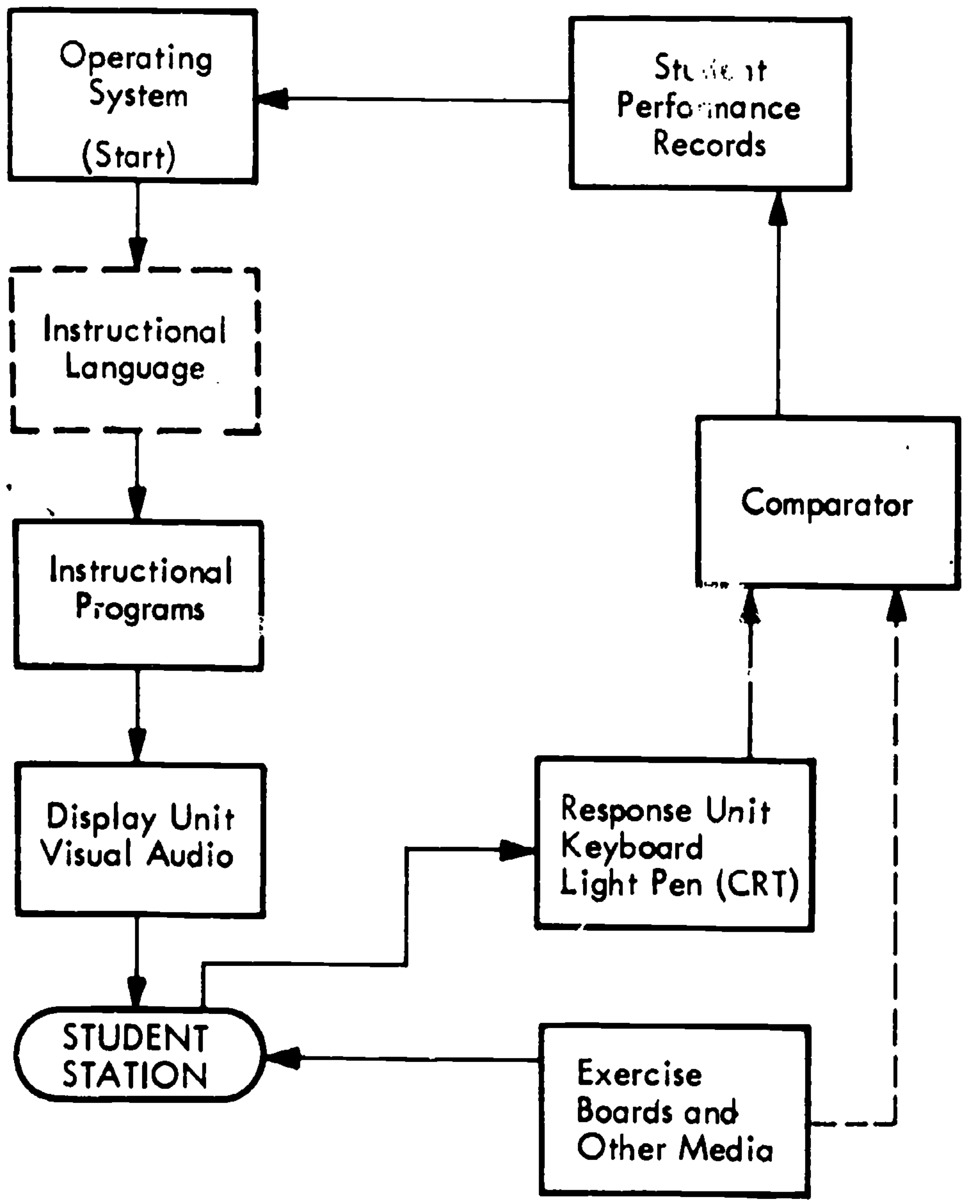


Figure 4-2. General Characteristics of USASCS CAI System

it will permit USASCS to apply those CAI methodologies identified earlier as being applicable to adapting electronics training for CAI presentation. It adapts instruction to the needs of the individual student, records and processes student administrative data, and provides instruction with a variety of media. Therefore, consideration should be given to a time-shared, student-station oriented system capable of presenting instructional material to approximately 21 students simultaneously.

The system should not be oriented toward any one instructional method so it will not restrict the course author from incorporating as many teaching techniques and media as are required to present course material.

The major functions performed by this operating system and instructional language application programs are to:

a. Assemble and store course material written in the instructional language

b. Supervise the presentation of course material

c. Schedule service requests so that each student station has access to the system facilities

d. Analyze student inquiries and responses

e. Specify presentation media

f. Record student responses

g. Provide information on the status of the system

h. Store and maintain all data needed by the programs executed under the operating system control.

The sections of the student station are:

a. Display Units
Visual (CRT, Image Projector)
Audio

b. Response Units
Keyboard
Light Pen (CRT)

The exercise boards and other media, as shown in Figure 4-2, are off-line, that is, not connected to the computer. In evaluating a CAI system, some consideration should be given to its capability to control these devices directly on-line. The major equipment components of the USASCS CAI system described above are depicted in Figure 4-3.

4.6 USASCS MANPOWER CONSIDERATIONS

Figure 4-4 describes an approach for developing and student testing CAI course material. To develop, implement and evaluate the effectiveness of approximately 150 hours of Basic Electronics and 30 hours of New Equipment Training, the USASCS will require the active participation of personnel with a variety of skills, working as a team. The type, number, and suggested duties of personnel who should form the base of a USASCS CAI project team are listed in the following subsections (categorized according to function).

4.6.1 Technical Direction and Administration

Personnel Type: Project Manager (1)
Technical Director (1)

Duties:

a. Is responsible for planning and directing the activities of all CAI project personnel in the development, testing, implementation, and evaluation of CAI course material

b. Coordinates the activities of contractor personnel (if required)

c. Coordinates, with other USASCS and USAECOM groups, those activities directly supporting the CAI project mission

d. Interacts with other CAI development groups

e. Prepares progress reports to inform management of project progress.

Personnel Type: Secretary (1)

Duties:

General secretarial duties.

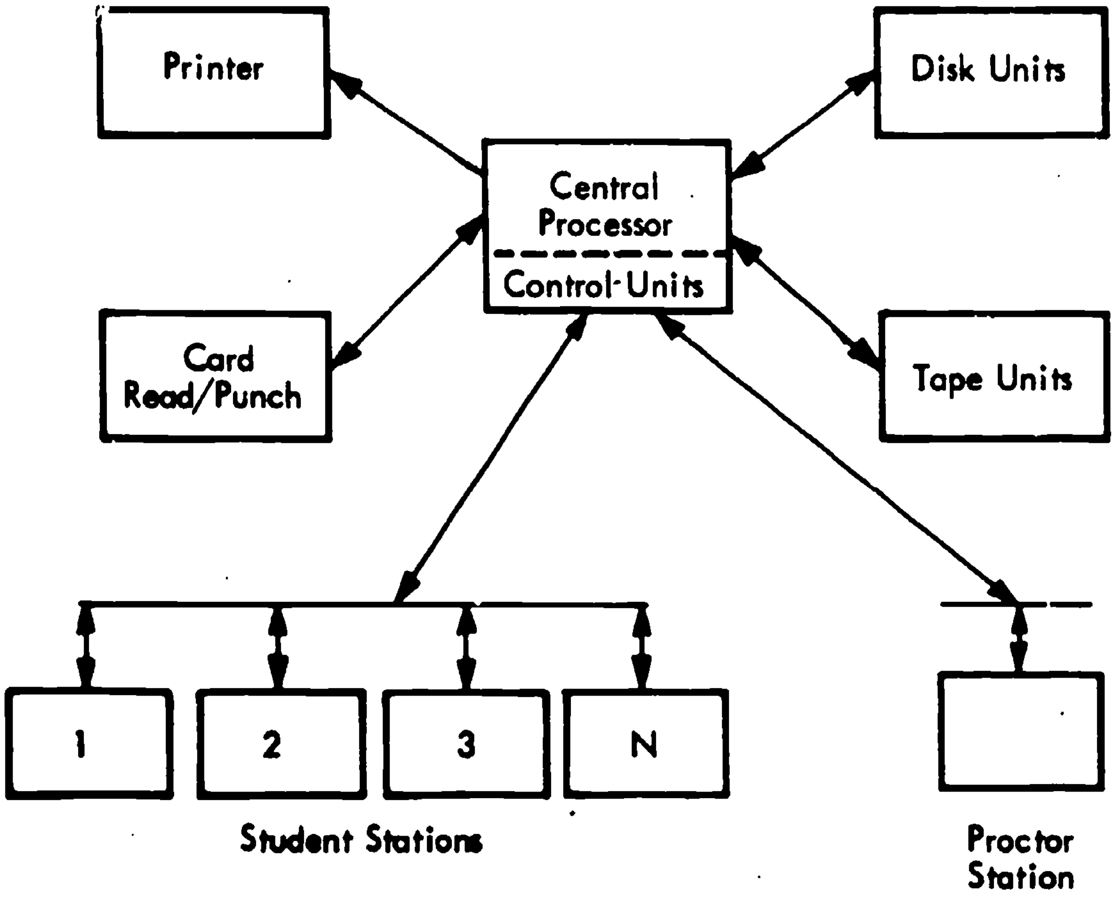


Figure 4-3. CAI Hardware Configuration

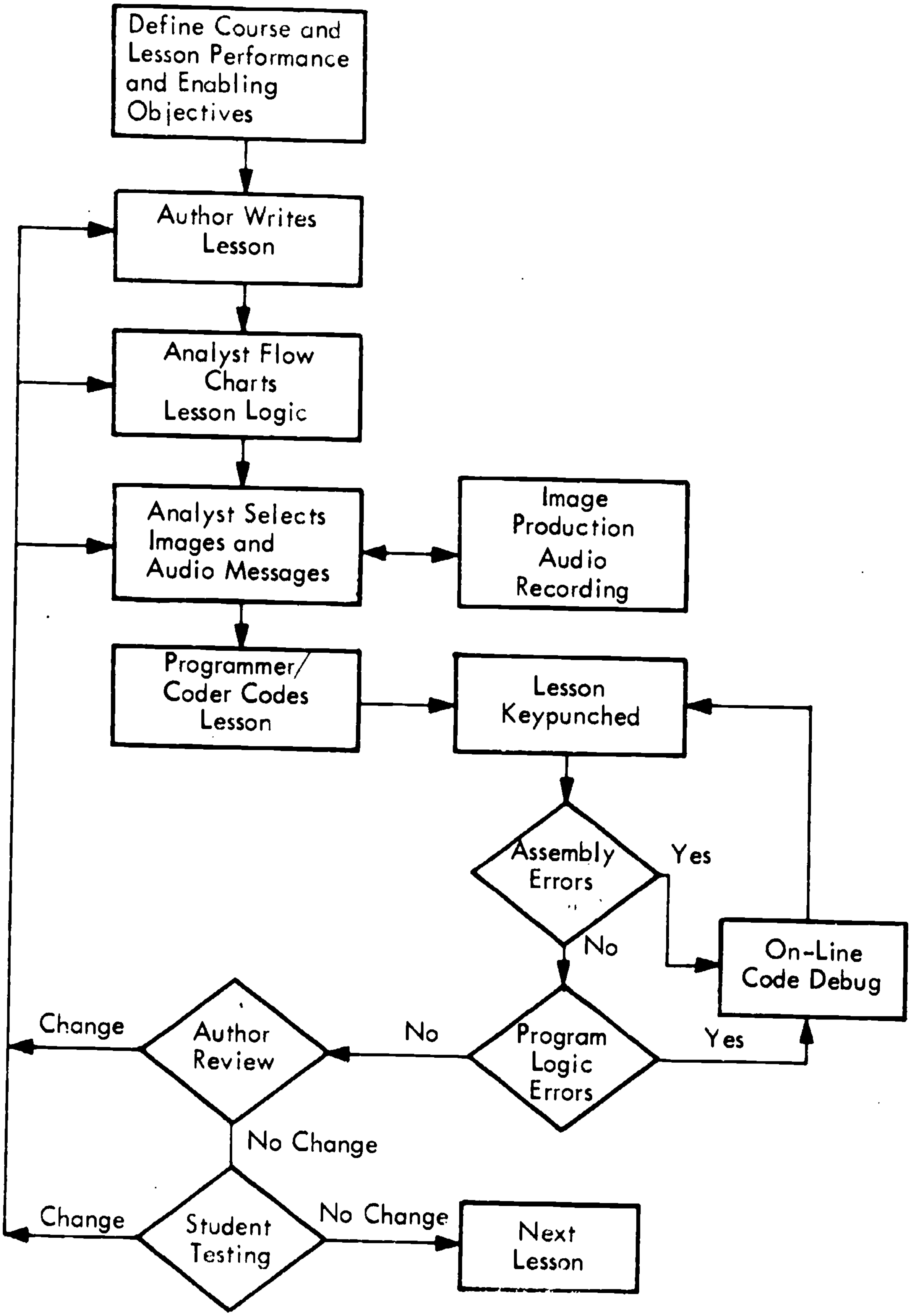


Figure 4-4. Development of CAI Course Lessons

Personnel Type: Clerk/Typist (2)

Duties:

General typing and record-keeping duties.

4.6.2 Analysis and Evaluation

Personnel Type: Audiovisual Analyst (1)

Duties:

a. Is responsible for consulting in the selection of graphic material used to implement visual portion of the author's program

b. Is responsible for advising in the selection of parts of the author's program which use audio messages

c. Is responsible for directing the activities of the audiovisual support group in the preparation of graphics and recording of audio messages.

Personnel Type: Engineer/Analyst (1)

Duties:

a. Is responsible for determining the types of functional training aids to be used in conjunction with the CAI system

b. Is responsible for the design and development of selected functional training aids

c. Is responsible for identifying and determining the modifications necessary to interface on-line training simulators or other media with the CAI system.

Personnel Type: Educational Psychologist (1)

Duties:

a. Consults in determining CAI methodologies

b. Serves as an advisor in developing requirements for branching and in evaluating instructional performance of developed lessons

c. Consults in the use of audiovisuals.

Personnel Type: Cost Analyst (1) **BEST COPY AVAILABLE**

Duties.

a. Is responsible for determining the significant cost factors used in comparing the cost of CAI with conventional methods of instruction

b. Is responsible for collecting significant cost data

c. Develops and exercises cost model to determine cost effectiveness of CAI.

Personnel Type: Experimental Psychologist (1)

Duties:

a. Is responsible for the design of all performance measures

b. Is responsible for the administration and collection of data resulting from controlled evaluations

c. Is responsible for the analysis and interpretation of evaluation data collected.

4.6.3 Course Development

Personnel Type: Educational Specialist (3)

Duties:

a. Defines course and lesson performance objectives and lesson enabling objectives

b. Schedules, directs, and coordinates the efforts of those authoring CAI course material

c. Monitors the progress of the course and the quality of its contents

d. Assists in defining course logic and in selecting audio-visuals

e. Determines instructional methodologies to be employed

f. Assists in administering controlled evaluation.

Personnel Type: Training Specialist (5)

Duties:

a. Is responsible for authoring course consistent with performance and enabling objectives

b. Assists in determining CAI methodologies

c. Flowcharts lesson logic and identifies presentation media.

Personnel Type: Subject Specialist (2)

Duties:

a. Is responsible for technical accuracy of course content

b. Assists in authoring course material

c. Assists in selecting graphics.

Personnel Type: Instructional Analyst/Programmer (3)

Duties:

a. Provides guidance in the application of the instructional language

b. Is responsible for flowcharting overall course logic

c. Monitors keypunch operator activities.

4.6.4 Programmer and Equipment Operations

Personnel Type: Systems Programmer (1)

Duties:

a. Is responsible for operating and maintaining systems programs

b. Defines and develops utility programs in support of course authoring and data analysis and reduction

c. Documents all program modifications.

Personnel Type: Equipment Operator (2)

Duties:

a. Operates computer and peripheral equipment

b. Determines needs for supplies

c. Schedules and maintains records on equipment use

d. Supervises keypunch operator personnel.

Personnel Type: Keypunch Operator (2)

Duties:

General keypunch operator duties.

The preceding personnel list does not include those skills required to prepare and process audiovisuals. It is recommended that this service be provided by existing USASCS support groups. Figure 4-5 summarizes the USASCS CAI manpower requirements.

4.7 REVIEW

This part of the study report provides USCONARC with evidence as to the applicability of CAI as a medium for training Army personnel in courses like Basic Electronics. Specifically, by reviewing the current status of available CAI system equipment and languages, it was possible to identify the USASCS resource requirements thought necessary to support implementation of Stage I of the USCONARC TDP.

The operational CAI equipment and languages used by universities, non-profit organizations, and private industry have demonstrated that the educational and training practice employed by the Army can be adapted to CAI. Presently CAI is being used to drill and teach, assess learning difficulties, and respond to students' progress to improve their instruction at several locations. Because many of the traditional instructional techniques are adaptable to CAI, routine responsibilities of the instructor are reduced, and therefore more of his time can be made available for instruction.

The majority of the surveyed CAI activities used off-the-shelf, commercially available CAI systems which in some cases were modified to fit the individual course developer's needs. A small percentage of the

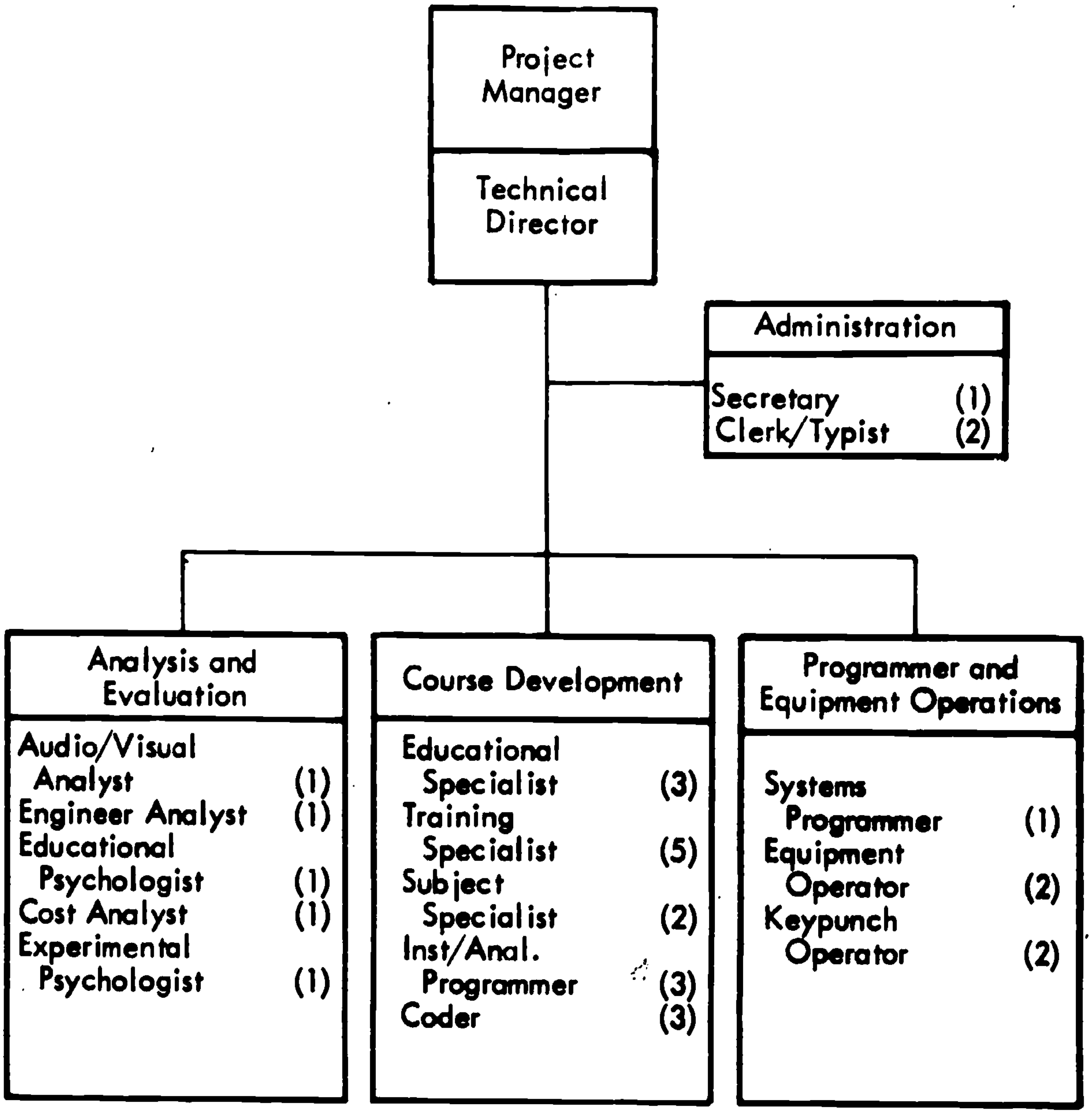


Figure 4-5. USASCS CAI Manpower Summary

applications used standard data processing equipment for which the developers had written their own language, operating, and utility programs and were employing a variety of input/output devices.

Looking ahead, one can see a useful application of CAI for training electronic maintenance technicians. The integration of practical exercises in the USCONARC CAI course involved equipment not under computer control. The next logical step in the development of CAI for application to maintenance training is the implementation of computer controlled equipment. Members of this study group have prepared a practical exercise for teaching the operation of a multimeter using CAI. The multimeter is directly connected to the computer. The development of this multimeter training unit parallels the work on Pennsylvania State University's audiometer trainer cited above (page 4-7).

As a result of comparing the standard instructional techniques presently employed during the 202 hours of Basic Electronics and 53 hours of New Equipment Training with applicable CAI methodologies, it was estimated that 150-160 hours (80%) of Basic Electronics and 25-35 hours (50 - 70%) of New Equipment Training were adaptable for CAI presentation. Based on these estimates of adaptable instructional hours and IBM experience in developing CAI course material, the general characteristics of a CAI system considered adequate to fit USASCS needs were described. Consistent with this systems' characteristics, the major hardware components of the system were identified and described.

It was generally concluded from this study task that a high percentage of the electronics training identified in the USCONARC TDP is adaptable for CAI presentation. It also appears that present state of the art commercial CAI hardware systems are sufficiently advanced to satisfy the USASCS requirements to support implementation of Stage I of the USCONARC TDP. It is therefore concluded that CAI is applicable for training USASCS personnel in basic electronics in particular and for Army training in general

Section 5

DISCUSSION

The evidence produced by this study demonstrates that CAI is effective and efficient as an instructional method and that it is applicable to training at USASCS and by implication to Army training in general.

As a first step toward demonstrating the effectiveness of CAI, a segment of basic electronics training was actually implemented on the IBM 1500 Instructional System. This implementation made use of the same course objectives used for the current training at USASCS. Working within the time frame of a six month study, the course was written, coded, and debugged in an unusually short period of time. Despite the time pressures, several innovations were included with the course. Animation was used on the CRT to demonstrate the attraction and repulsion of charged bodies. A glossary feature was included to present reference material to the student at his demand. Practical exercises, incorporating "hands-on" experience, were used to introduce basic concepts and offer practice in using the multimeter.

The effectiveness of this implementation in teaching students was demonstrated by means of a controlled experiment. A criterion test, used to measure performance of students trained by CAI and conventional methods, was developed from the course objectives with the concurrence of the USASCS Department of Specialist Training. A methodology was devised to select sample students based on their predicted performance in the course. The high, average, and low students in the test sample represented the range of aptitudes in the student population at USASCS. Equivalence between the CAI students and the conventionally trained students was demonstrated by their performance on a pretest administered prior to actual instruction. The performance of the students on the post test, administered following instruction, showed that the CAI course was as effective a teaching method as the conventional methods currently in use at the school. Thus, the implementation of a portion of USASCS training and demonstration that the course teaches as well as conventional instruction established the effectiveness of CAI as a method of instruction.

The efficiency of CAI was demonstrated by comparing the cost of CAI training with the cost of conventional instruction. The data obtained from the Signal School at Fort Monmouth was used to derive the cost of current training, which was distributed to a cost-per-student-hour. With this basic unit, the cost of any particular course graduate could be computed. CAI costs were estimated using those data which were available. The main variables in the computation of the student hour cost with CAI are amortization schedules of hardware costs, daily usage rate of the system, and potential savings in student training time. When favorable decisions concerning amortization and usage are made, CAI costs begin to approach conventional costs. When savings in student training time of 20% are included in the model, the costs of CAI become competitive with conventional costs. An estimate of a 20% saving in student time does not appear unrealistic in view of a demonstrated saving of more than 11% with the sample of students used in the effectiveness study. Considering that there was insufficient time to adequately test and revise the instructional program, the potential savings which might be achieved with refinement can only be estimated. Finally, it must be realized that CAI is still a developmental activity. When more standardized, production-type procedures are implemented, the efficiency of CAI should improve over the estimates presented in this study.

After effectiveness and efficiency were established, the final task was to demonstrate the applicability of CAI to USASCS training requirements in particular and Army training requirements in general. The fact that a portion of the basic electronics training at USASCS was effectively implemented indicates the applicability of CAI. In addition, three other points were made in the study: the availability of equipment, the proportion of current USASCS training which evidently can be converted to CAI, and the identification of USASCS and Army training practices which are being implemented using CAI elsewhere.

Three computer systems, specifically designed for CAI, were commercially available at the time of this study. Non-proprietary information available on two systems was presented and the IBM 1500 Instructional System described in detail. A fourth system had been announced but would not be available before mid-1968. With three systems currently available, obtaining adequate computer hardware for CAI should present no problem.

To evaluate to what extent CAI might be applied at USASCS, two courses were analyzed to determine the methods of instruction currently

in use. One of the courses (26L20) was chosen to represent courses taught in Basic Electronics training. The other (AN/GRC-103) was selected as representative of New Equipment Training. It was pointed out that experience has shown material taught by television, conference/ lecture, programmed instruction, and examinations can be effectively converted to CAI. Using this criterion, approximately 80% of Basic Electronics courses and 50 - 70% of New Equipment Training could be implemented on CAI. If the cost of simulators is not prohibitive, CAI could be used for an even larger proportion of USASCS training.

Evidence was presented to demonstrate that, despite the fact that CAI is still a developing technology, most if not all of the training practices in use at USASCS have been or are currently being effectively implemented with CAI systems. Three general classifications of training practices were identified and numerous examples of implementations were presented from the published literature.

This study, then, presents evidence that CAI is an effective and efficient training method. Moreover, CAI is shown to be applicable to the training requirements at USASCS. To the extent that these requirements reflect requirements of Army training in general, this evidence presents the same implications for the Army as a whole.

Section 6

CONCLUSIONS AND RECOMMENDATIONS

It is feasible to use CAI as an instructional method in Army training. Feasibility was demonstrated in terms of the effectiveness, the efficiency and the applicability of CAI in satisfying USASCS and U.S. Army training requirements.

a. <u>CAI Effectiveness</u> — A course of instruction, based on USASCS course objectives, was implemented on the IBM 1500 Instructional System. A sample of students representing the range of aptitudes found at USASCS was trained via CAI and compared on a criterion test with performance of equivalent groups of students trained by television and instructor-controlled methods of instruction. The performance data demonstrated that training via CAI was as effective as training via television and instructor control. Moreover, the CAI students required 11% less time on the average to complete the training than the television and instructor-controlled method students.

b. <u>CAI Efficiency</u>— When current training costs were compared with estimated CAI costs, it was shown that in the worst case CAI costs are not prohibitive. Favorable decisions concerning amortization and system usage improve the CAI cost picture. When potential savings in student training time through the use of CAI are included, CAI becomes cost-competitive with conventional training costs.

c. <u>CAI Applicability</u>—In addition to the fact that a portion of USASCS training was effectively implemented, the applicability of CAI to USASCS requirements was demonstrated in three ways. Three commercially available systems were identified which could satisfy USASCS requirements. Analysis of representative courses at USASCS showed that a significant portion of existing courses could be converted readily to CAI. Finally, three general classes of instructional practices in use at USASCS were identified, and the ability of CAI at the present state of the art to handle these practices was demonstrated by citing actual examples of implementations from the published literature.

Based on the three criteria, effectiveness, efficiency and applicability, the results of this study lead inevitably to the conclusion that it is feasible to use CAI as an instructional method in Army training.

This conclusion leads to the recommendation that USASCS continue its effort in CAI. Several advantages can accrue to the U.S. Army from a continuing effort. The immediate result is the development of an in-house capability. Such a capability would place USASCS and the Army in a unique position to evaluate and capitalize upon new advances in CAI technology as they develop. During this period of growth, USASCS could use its capability to systematically investigate the problems of the reduction of training time and the training of lower aptitude students. The results of such investigations could have significant implications throughout the Army and Department of Defense.

It is recommended that the Army use a modular approach to develop its in-house CAI capability. For example, rather than attempting to adapt an entire Basic Electronics course to CAI at one time, a more efficient and prudent approach would be to develop this course in increments consistent with natural breaks in the course content. This modular path to CAI development will make possible the immediate exploitation of experience during the step-by-step process of CAI course development. As a result the need for extensive revision of the entire course will be minimized. In addition, because the state of the art of CAI is advancing rapidly, the modular approach will facilitate incorporation of up-to-date advances without extensive course alteration.

APPENDIX A

THE DEVELOPMENT OF THE COURSE SEGMENT

A.1 INTRODUCTION

This Appendix describes the events and activities leading to the development of a Computer Assisted Instruction course segment. The material included in this course is described in the introduction to the report. It was converted to a CAI format and implemented on the IBM 1500 Instructional System. The procedures followed in carrying out the conversion and implementation are described below. One of the factors having a direct bearing on the course development was the four to five month period allocated for the task.

A basic principle of CAI is that each student can learn a concept or subject according to his particular requirements. This not only means that each student may learn as quickly as possible, but also that the amount and content of material presented may be tailored to his individual needs. Probably the best design to achieve this principle is one containing multiple instructional tracks. This allows the brighter students to receive enriched material while slower students learn the basic fundamentals, each at his own rate of absorption. Students are positioned and switched from one track to another, depending on their ability.

Because a multi-track design would require more than four months to develop, an alternative method incorporating a single track linear progression and containing characteristics approximating the multi-track design was selected. Features included a pretest to advance knowledgeable students, query logic offering remedial help and simulating explicit branching techniques, summary material for reinforcement, use of a glossary for technical vocabulary, and computer-controlled practical exercises to provide hands-on training. The level of instruction was geared to the majority of students at the Signal School who have completed high school (12 years).

Three groups of personnel developed the course—authors, a subject matter expert, and programmers. The authors were responsible for designing the overall logic, the course writing, and revising. The subject matter expert ensured that the material was accurate and complete. The programmers were responsible for implementing the material on the computer. This task included creating a program design to operate upon the course logic, converting the material to a computer language, and debugging.

Prior to the actual course administration, sample students were sent through whatever parts of the material were available. These included IBM personnel and three groups of two students each from Ft. Monmouth. During these sessions, student performance recordings containing all pertinent information relating to a given response were generated. The author responsible for course writing used these records to locate subject matter areas which resulted in a common source of student difficulty. These areas were then revised. The programmers also benefited from this review process, since many of the program "bugs" were discovered by the sample students and then corrected.

A. 1. 1 Content of Basic Electronics Course Segment

When the selection of the CAI portion was completed, a detailed specification of the course content was commenced. This was accomplished by delineating the course objectives and reviewing current basic electronics material.

A. 1. 2 Objectives

Since effectiveness was to be determined by a comparison of CAI with the classroom instruction at USASCS, the objectives used to develop CAI material were the same as those defined by the school. These objectives are contained in Lesson Plan 280. 0-1-LP (25-38), dated 3 January 1967, Department of Specialist Training, Fort Monmouth, New Jersey. During the early stages of course development, the USASCS provided IBM with a detailed set of performance and enabling objectives.

A. 1. 3 Reference Sources

The manuals referenced by the CAI authors were those supplied to the students by the school during conventional instruction, including the Department of Army Technical Manual TM 11-661, Electrical Fundamentals (Direct Current), and associated Self-Tutor Texts (SSTS). In addition, the authors observed the actual classroom instruction to understand the current instructional methods.

A. 1. 4 1500 System Configuration

The 1500 Instructional System was developed specifically for computer-assisted instruction. It is designed to present material through several different media at instructional stations. Each station consists of a cathode ray tube (CRT) display with light pen and keyboard, a typewriter, and an image projector.

a. CRT Display -- The CRT screen permits a display of any pattern, character, or graphic (picture) by illumination of light dots (61,440 dots on the face of the tube). Each character occupies an 8 x 12-dot area. A total of 640 characters may be displayed on the screen at one time. A graphic may be any combination of dots which the user chooses, ranging in size from an 8 x 12-dot area to the entire screen, a 192 x 320-dot area. The system provides a character set of 128 symbols, including upper and lower case alphabetic, numeric and special characters. The user may generate additional graphics. Each line holds 40 characters. The time it takes to change a display is 1/30 second. There are two ways for a student to enter a response. The first is by typing on the keyboard placed at the base of the screen. The second way is by pointing with a light pen. The student points to a location on the screen which is then picked up by the computer as a pair of coordinates.

b. Image Projector -- This device holds a 9 x 7-inch display screen on which color or black and white images can be projected from 16 millimeter film. Interchangeable cartridges containing the film strips are inserted at the instructional station. The film, automatically threaded by the projector, can show as many as 1000 images in any sequence, as directed by the course program.

c. Typewriter -- This unit is similar to an IBM Selectric Typewriter. The changeable typing element contains 88 characters. As many as 130 characters may be typed on one line. Material may be typed out by the system at a maximum speed of 15 characters per second. Inputting may be done only via the keyboard.

There are three alternatives in presenting the instructional media. Since the image projector cannot be used as an input device, it is included as a supplementary output device in the following alternatives:

a. All course material presented on typewriter

b. All course material displayed on CRT

c. Combination of these.

There are several advantages to using the CRT:

a. Rapid presentation of instructional material

b. Minimal format limitations

c. Input via light pen or keyboard

d. Unlimited character set, including graphics.

The versatility of the CRT was the basis on which this device was selected over the use of the typewriter for input. To eliminate the disadvantage of "no hard copy," the student was given a previously prepared booklet containing summaries of each segment and lesson. As each student finished his first computer session, he received a copy of this booklet to review as needed.

For the purposes of this experiment the typewriter was removed, so the instructional station contained CRT, with light pen and keyboard, and image projector (Figure A-1).

A.2 COURSE ORGANIZATION

Material to be taught with CAI must be logically ordered and complete. It must also simulate the conventional classroom environment by providing the student with the attention and direction offered by an instructor, though on a one to one basis. Thus, students who are able to grasp and retain subject matter with a minimum of explanation may advance to new material in accordance with their ability; those having previous knowledge may accelerate. Slower students may be directed to alternate presentations, drills, and exercises that allow them to learn at a slower pace.

The organization of the material controls the instructional presentation. Six elements comprise the current course structure: segment, lesson, pretest, lesson test, summary, and practical exercises.

a. Segment -- a division of the course into a logical entity of related information. The segment may be equated to a chapter of a book plus the classroom periods necessary for a teacher to cover the chapter contents. Each of the following structural elements exists within the segment as an individual section (Figure A-2). There are four segments in this course:

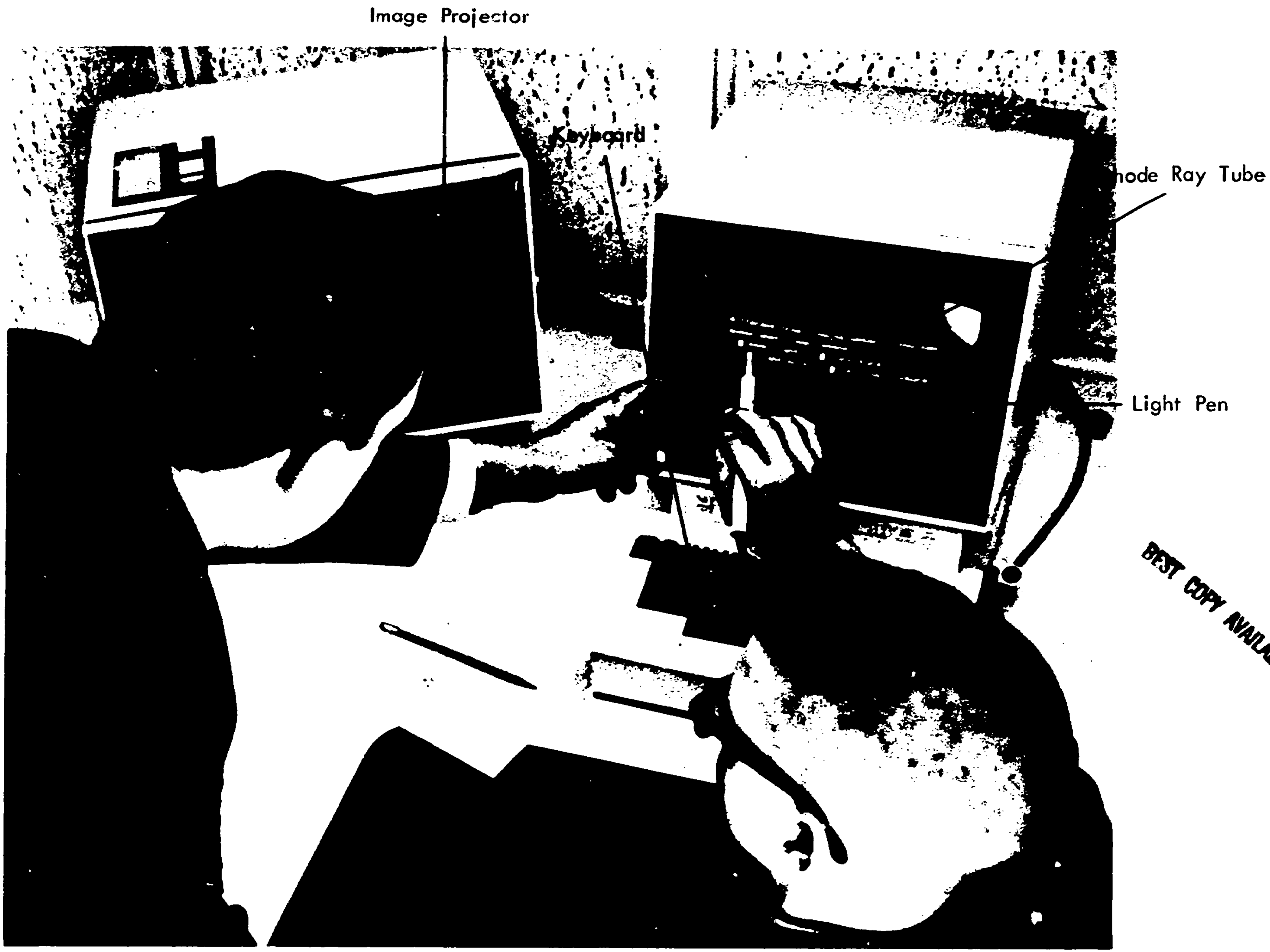


Figure A-1. IBM 1500 Instructional System - Student Station

Segment I

Pretest

Lesson I. A.

Instructional Frame (1) — Teaches all concepts involved in the lesson

Instructional Frame (2)

Instructional Frame (3)

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Instructional Frame (n)

Lesson Test I. A.

Lesson Summary I. A.

Lesson Practical Exercise - optional

Lesson I. B.

Lesson Test I. B.

Lesson Summary I. B.

Lesson Practical Exercise - optional

Lesson I. B.

Lesson Test I. B.

Lesson Summary I. B.

Lesson Practical Exercise - optional

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Lesson I. Z.

Lesson Test I. Z.

Lesson Summary I. Z.

Lesson Practical Exercise - optional

Segment II

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Figure A-2. General Course Format

1. Introduction to Basic Electricity
2. Meters -- Use as Ammeter and Voltmeter
3. Batteries -- Characteristics and Connections
4. Resistors -- Color Code and Use of Ohmmeter.

In addition, two other segments have been included as supplementary topics. The first, called Intro, prepares the student for the CAI portion by teaching him how to use the equipment contained at the student stations. The student is shown the various input methods (light pen, keyboard, backspace, and erase), course messages ("You're taking too much time", "You missed the target", "You've now finished this segment", etc.), and general procedures (use of glossary, signing on and off). The second segment, called Conversion of Units, presents a review of the measurement prefixes used in the course—micro, milli, kilo and mega—and illustrates their use.

b. Lesson -- an individual part of a segment containing instruction on interrelated concepts. The lesson is made up of units called instructional frames (IF). An instructional frame contains textual information, an optional slide presentation, and remedial help in the form of one or more questions which will be referred to as IF questions to differentiate them from pretest and lesson test questions. The text portion is limited to three pages of CRT display. A page is defined as a display having a maximum of 300 characters with an optional graphic illustration. The IF questions measure the student's understanding of instructional concepts. Each IF question has up to three hints and several answers associated with it. When a student responds incorrectly, an appropriate hint appears and he is given another try at the question. After the last hint has been shown and his response is still incorrect, the student is given the answer and told to input it. If he does not enter the correct answer, this last procedure is repeated until he does. Figure A-3 presents the general instructional frame flow and Table A-1 contains a list of the lessons included in the course.

c. Pretest -- a set of questions pertaining to all segment objectives. The pretest is used to determine whether a student has sufficient previous knowledge of the subject matter to bypass

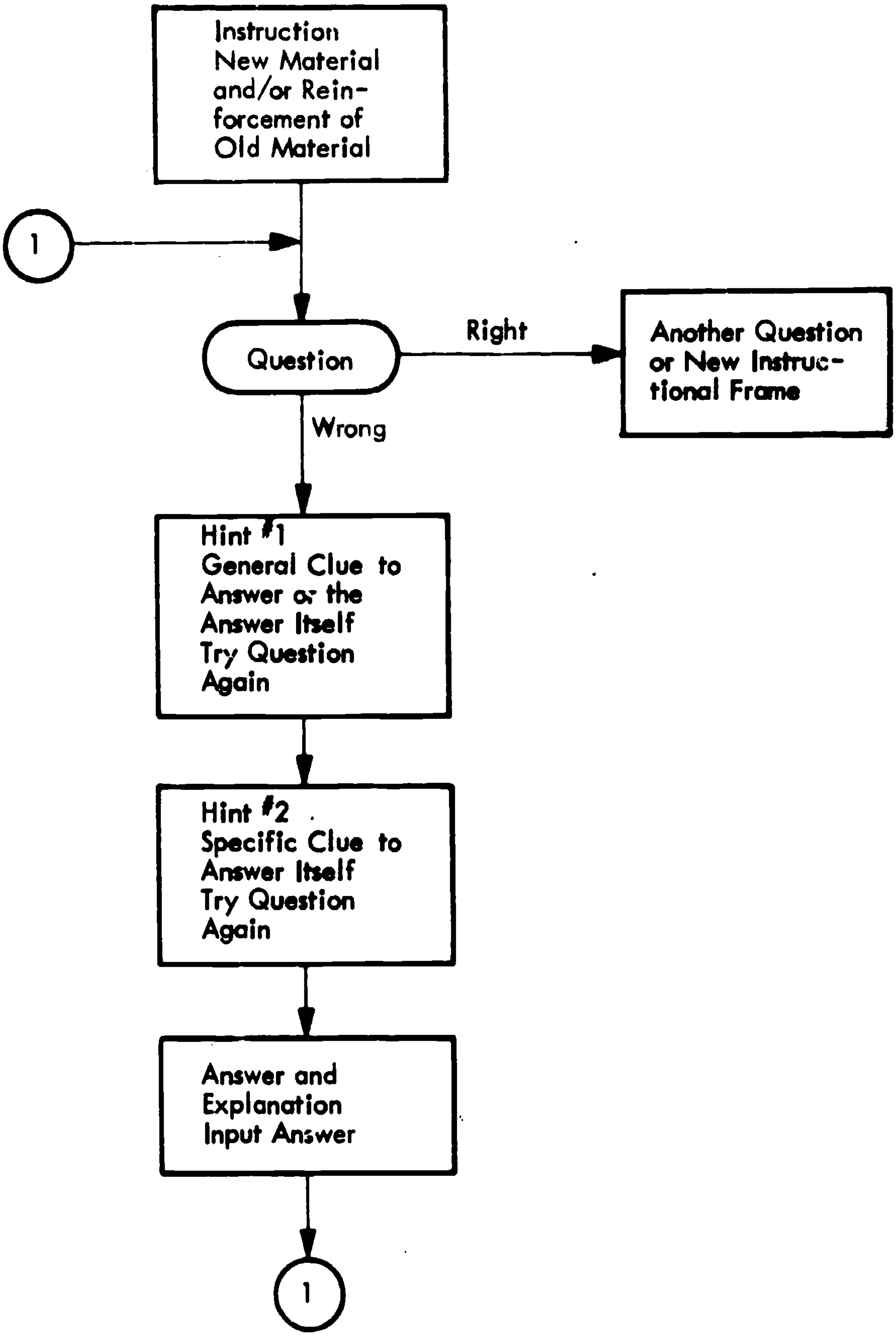


Figure A-3. Instructional Frame Flow

Table A-1

COURSE LESSON SEGMENTS

Listed below are the lessons in the course and the segments containing them:

SEGMENT	LESSONS
Introduction to Basic Electricity	Use and Purpose Survey Survey Practical Exercise Electron Theory Voltage Resistance Current
Meter - Use as Ammeter and Voltmeter	Introduction to Meters DC Voltage DC Voltage Practical Exercise AC Voltage DC Current
Batteries - Characteristics and Connections	Introduction to Batteries Series Battery Connections Parallel Battery Connections Series - Parallel Battery Connections
Resistors - Color Code and Use of Ohmmeter	Introduction to Resistors Color Codes Ohmmeter Ohmmeter Practical Exercise

specific lessons. When a student begins a new segment, he is given the pretest. He is told not to spend too much time on any one question nor to guess at an answer. To speed the process for a student who does not know the material, there is an "I don't know" choice available on each pretest question. The questions are grouped by lesson objective. That is, the first group of questions relates to concepts involved in the first lesson, the second group with the second lesson, and so on. As each group is completed, it is analyzed to determine if the student passes or fails. Passing is a minimum score of 80%. If the student passes, the associated lesson will be skipped and the next group within the pretest given. If he fails, the student is informed that the pretest is over and then directed to the appropriate lesson. From that point on until the next segment, he proceeds with one lesson after another. It is possible for a student to pass the entire pretest and thereby ship all segment lessons. When this occurs, the student is told that he is bypassing the segment instruction and will receive the next segment pretest. Figure A-4 illustrates the general pretest logic.

d. Lesson Test -- test questions pertaining to lesson concepts. These questions are similar to or identical with the corresponding lesson group of the pretest set. At the end of each lesson, the student gets the lesson test. He is presented with these questions one after another, without any feedback from the computer as to their being right or wrong. If, upon completing the test, the student has missed any questions, he is presented with the Summary and then those questions he missed. As he responds this time, the computer checks the answer. If it is incorrect, an explanation of the answer is displayed for use as remedial help.

e. Summary -- a review of the key points contained in the lesson. It is presented only to those students missing one or more of the lesson test questions.

f. Practical Exercise -- units of a segment devoted to hands-on training. The transition from classroom theory to practical application is sometimes a difficult process. It is extremely important that a student begin using the equipment in the proper manner and that these procedures are reinforced

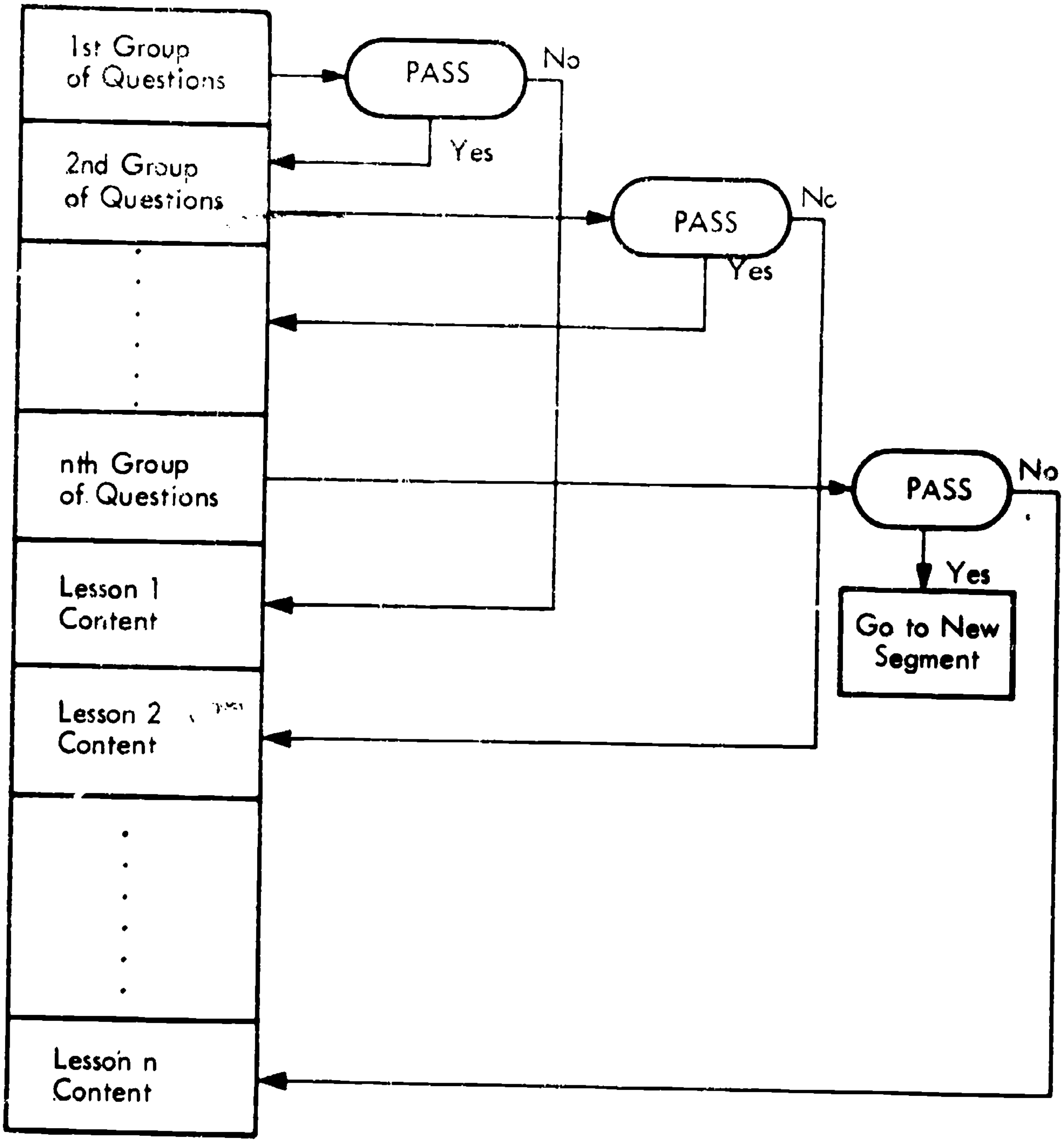


Figure A-4. General Pretest Logic

rather than for him to have to unlearn and restart because of improper usage. For this reason, the practical exercises are designed to guide and student through the operation of his equipment under computer control. Each time the student performs a new manipulation, he inputs his response. If it is incorrect, a description of the proper procedure is displayed. The student then corrects the operation and continues. There are three practical exercises in the course. The first consists of a simple circuit containing two batteries, a rheostat a lamp, and a switch. The student is able to see the relationship of resistance to current by varying the resistance in the rheostat and observing the changing brightness in the lamp. The second requires the student to set up his multimeter as a voltmeter and record the voltage readings taken across various terminal points of five connected batteries. In the third practical exercise, the student is asked to use the multimeter as an ohmmeter to measure the value of a set of resistors. Figure A-5 presents the general course logic flow.

A.3 INSTRUCTIONAL STRATEGIES AND TECHNIQUES

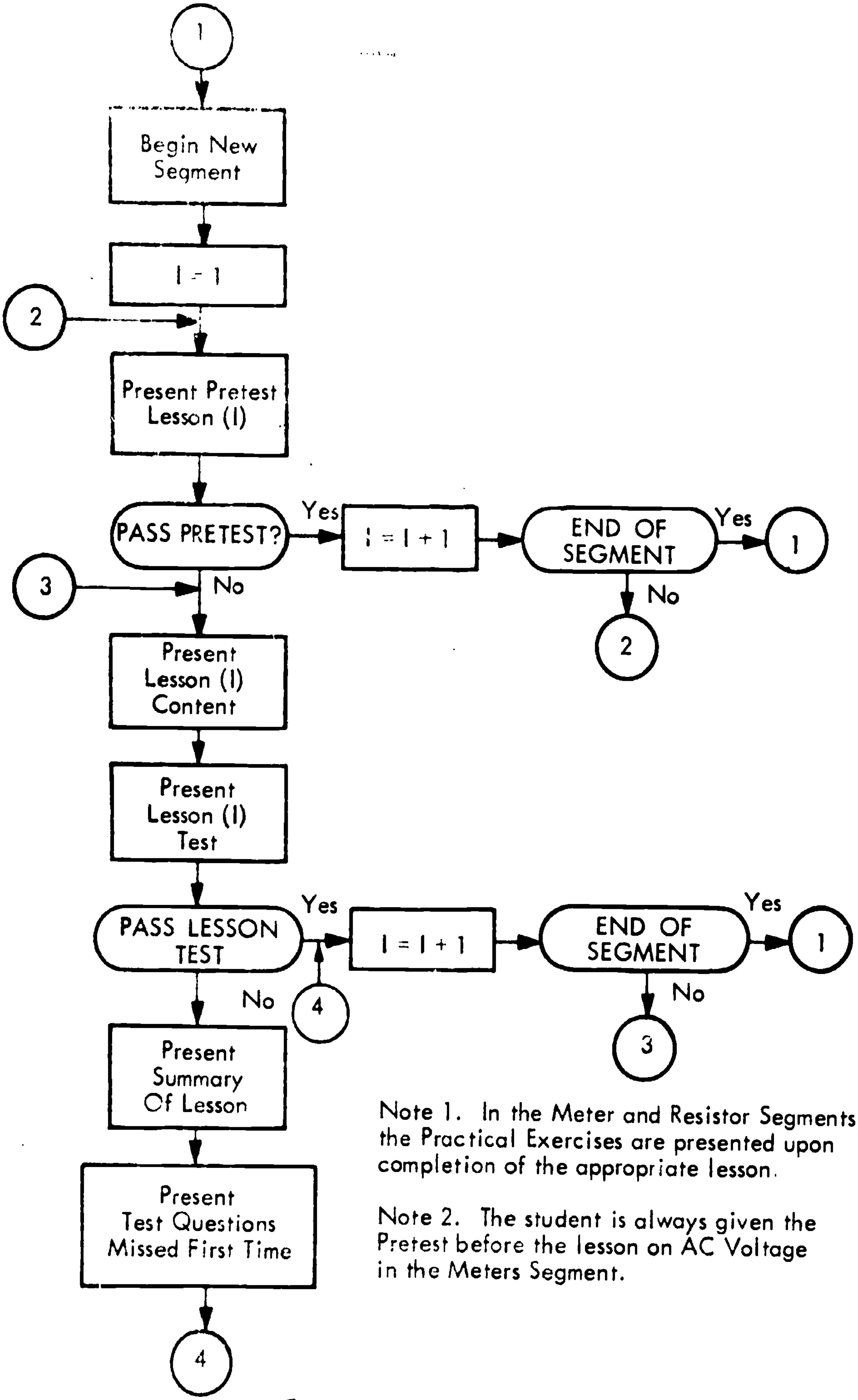
An important part of this course design is the organization, which has been previously described. A description of the strategies and techniques completes this section.

A.3.1 Strategies

The majority of questions were multiple choice with four alternatives. Since the student uses the light pen in pointing to an answer, inputting errors (e.g., typing a wrong letter, misspelling a word) and complexity of computer error analysis are minimized. Constructed response (fill-in type) questions, used infrequently, were included when required by the terminal performance objectives.

The student is allowed to progress at his own rate during the instructional frame portions of the lesson. There is no limitation on how long he may take to read a specific textual presentation or respond to an IF question.

The pretest and lesson test questions have a two-minute response limit. If a student has not responded within the given time, the answer is considered incorrect.



Note 1. In the Meter and Resistor Segments, the Practical Exercises are presented upon completion of the appropriate lesson.

Note 2. The student is always given the Pretest before the lesson on AC Voltage in the Meters Segment.

Figure A-5. General Course Logic Flow

All IF questions must be answered correctly before the student will be allowed to continue in the course. Figure A-6 gives the general course logic for each lesson.

Computer analysis follows each question within the pretest set. When 20% of a group has been missed, no further segment pretest questions are presented. Figure A-4 shows the pretest section of the course logic.

The student is kept aware of his position in the course and of what material is just ahead. All structural elements (segment, lesson, etc.) have their own introduction, title, and a description of the contents.

The student is kept informed of his academic achievements. For the IF questions, he has an immediate feedback. At the end of each lesson test a message states the number of questions answered correctly out of the total number. After the pretest group, the student is told whether his answers indicate he knows the material and it can be skipped, or whether he must take the instructional lesson.

Since this material is an introduction to basic electronics, the student is required to learn many new terms and concepts. To help accomplish this, a glossary containing definitions and explanations of key items is available for use by the student during any IF question. When a request for the glossary is initiated, a list of those items previously taught (as the student progresses through the course, more and more terms are accessible) are displayed. The student can then choose one or more of these and receive an explanation of each item. Upon finishing with the glossary, he is returned to the IF question.

At the end of each day's computer session the student is given a booklet containing a summary of the material just covered. This helps the student with his review prior to the next computer session.

The role of the proctor in CAI is to assist students in completing the course with minimal interference. Along with setting up equipment for the practical exercises, he ensures that a student continues to progress with the material.

A.3.2 Techniques

The following CAI techniques were employed:

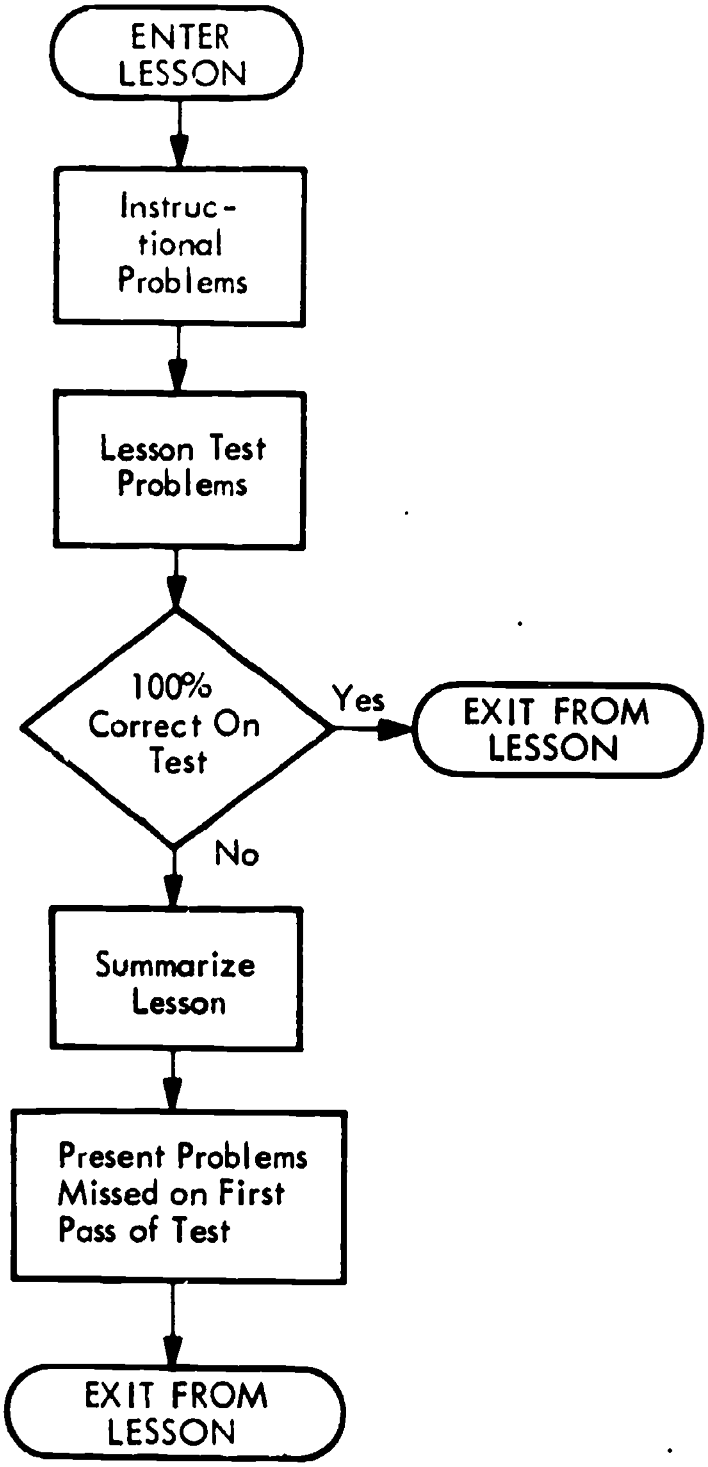


Figure A-6. Instructional Lesson Flowchart

a. Rolling out effect -- Words and sentences roll out in the CRT in time with the student's reading. This has the effect of varying the format of each CRT display.

b. Underline -- Specified words and sentences are underlined for emphasis.

c. Multi-media -- The image projector in color and the CRT supplement each other.

d. Blinking effect -- Specified words and sentences are blinked on and off to stress their importance. This technique is used mainly to indicate those terms being placed in the glossary.

e. Special characters -- Symbols are displayed, such as μ for the prefix micro.

f. Graphics -- Special pictures are presented on the CRT along with textual information. An example of a graphic is the schematic representation of a closed circuit containing two batteries and one resistor.

g. Animation -- Movement is used to illustrate some of the concepts. For example, the student is taught that LIKE charges repel each other and sees + signs (positive charges) moving away from one another on the screen; and that UNLIKE charges attract each other and sees + signs and - signs (negative charges) moving toward each other.

A.4 COURSE WRITING

When the logic design was completed, effort was directed toward the actual course writing. Three groups were primarily responsible for this phase: authors, a subject matter expert, and artists. Procedures were established to maintain team coordination and insure uniformity and completeness of the material. These are now described in task order.

a. Detailed Set of Objectives/Segment - The authors completed the Segment Header Sheet by choosing from the overall course objectives those relevant to their segment. Lessons were then defined in accordance with these objectives (Figure A-7).

Segment Name

Introduction to Electricity

Number of Lessons

6

Lesson Titles

1. Introduction
2. Survey.
3. Electron Theory
4. Voltage
5. Resistance
6. Current

Segment Objectives The student will, when given incomplete or fill in sentences:

1. State the effect on current of varying resistance or voltage
2. State the direction of current flow.
3. State the effect on current of an open, closed, or short circuit.
4. State the electron theory of electricity
5. Identify conductors and non-conductors, and give examples
6. Use correctly a score of technical terms.
7. Identify correctly a score of symbols and abbreviations.

Segment I.D.

1

Author

HAB

Figure A-7. Segment Header Sheet

b. Detailed Set of Objectives/Lesson - The Lesson Header Sheet, one per lesson, was completed. The lesson objectives were a refinement of the segment objective. Items placed under the previous concepts portion are used to relate material in different segments and lessons (Figure A-8).

c. Detailed Set of Pretest and Lesson Test Questions - The authors generated test questions based on segment and lesson objectives. This technique ensured that the authors were thoroughly familiar with the objectives and that their resultant instruction, guided by the test criteria, covered these objectives.

d. Definition and Usage of Terms - Each author submitted a list of terms he introduced along with those he assumed to have been previously defined. These lists were then compiled on one sheet for distribution to all authors and the subject matter expert. Discrepancies were eliminated and a common terminology established throughout the material. The authors then designated which terms they wished to have included in the Glossary.

e. Course Writing - The authors wrote their material. This includes selection of material, construction of IF questions, specification of slides and graphics, specification of answers, both correct and incorrect; use of practical exercises; and format of summary. Several forms were created for this task to identify areas within the course structure.

1. Text Sheet - Used for stating questions and instructional information. All material slated to appear on one page of a CRT display, except for incorrect response displays (hints, explanations, answers), was contained on these sheets (Figure A-9).

2. Answer Analysis Sheet - Used for hints, explanations, and answers to all questions (pretest, lesson, and IF), (Figure A-10).

3. Slide Sheet - Used by authors for drawing preliminary pictures (Figure A-11).

4. Graphic Sheet - Used by authors in sketching preliminary graphics (Figure A-12).

Lesson Title

Voltage

Lesson Number

5

Purpose

Student will understand the importance of voltage in the operation of electrical equipment.

Concepts Previously Acquired

1. Electricity is important to us.
2. Voltage is a force, measured in volts.
3. All material has resistance, measured in ohms.
4. Current is measured in amperes.
5. Three types of circuits are open, closed and short.
6. Electron theory explains actions of electricity.

Lesson Objectives - The student will, given an incomplete sentence or choice of responses:

1. Identify emf,
2. State the effect of varying voltage.
3. Identify two main sources of electricity.
4. State direction of current flow.
5. State characteristics of ac and dc.

Figure A-8. Lesson Header Sheet

Author

JKS

Date

7/15/67

Page

1

Frame Number

B0303

Type

Q

Textual Material

The two batteries below are connected in ______ since they lie end to end with a single path for the current. (Fill in the missing word).

Graphic I. D. (Optional)

BG01

Slide I.D. (Optional)

Figure A-9. Text Sheet

Author
jlc

Date
7/17/67

Page
1

Frame Number
B0303

Answer Analysis Logic
Ca Series
UN Batteries are connected in SERIES if
they are joined end to end. Fill
in the word SERIES as the correct
answer.

Graphic I.D. (Optional)

Slide I.D. (Optional)

Figure A-10. Answer Analysis Sheet

Slide Number

B528

Date

7/22/67

Page

1

Illustrations

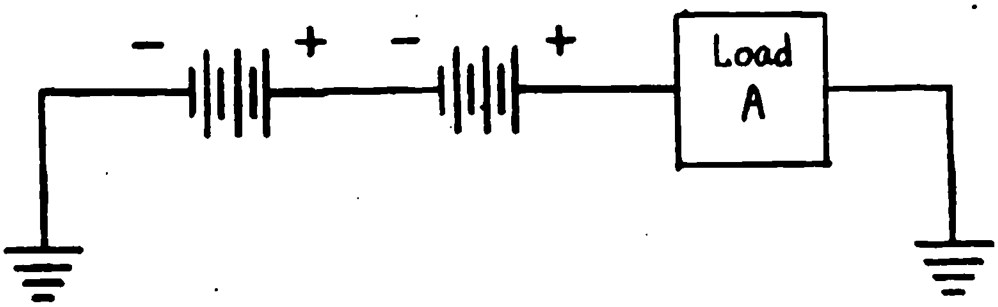


Figure A-11. Slide Sheet

Graphic Sheet

Date

Page

23G01

7/15/67

1

Illustration

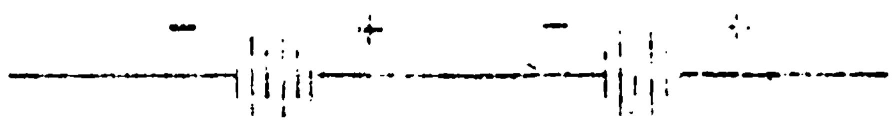


Figure A-12. Graphic Sheet

A description of the Test Sheet and Answer Analysis Sheet contents follows:

a. Frame Number - Identifies an Instructional Frame. It contains segment identification (ID), lesson ID, and frame ID. The segment ID is a single letter unique to each segment. The lesson ID is a sequential number beginning with 0 for the segment pretest. The frame ID is a sequential number beginning with 1 for each lesson. An example of a frame number is B0433 where B represents the battery segment, 04 the fourth lesson in B, and 33 the thirty-third instructional frame within the fourth lesson.

b. Type - Designates the type of display, using one of the following three letters: I, Q, or T. I stands for instructional or summary material, Q for instructional frame (IF) question, and T for pretest or lesson test question.

c. Textual Material - Contains display contents. Special techniques such as words to be underlined, blinked, etc., are indicated here.

d. Graphic or Slide ID - Comprised of segment ID, display ID (S for Slide, G for Graphic), and sequential number from 01 for each segment. Where more than one segment uses the same slide or graphic, the first segment specifies the segment ID.

e. Answer Analysis Logic - Contains the correct answer to a question, anticipated wrong answers along with an explanation of why the answer is wrong, and general hints and explanations for other responses.

f. Subject Matter Specialist Review - At various points during the writing phase, the authors and subject matter specialist convened to review the material for accuracy and clarity. They discussed the types of exercise boards desired by the authors. The subject matter specialist was responsible for designing these boards and having them produced. After these reviews, the graphics were turned over to programming personnel for implementation and the pictures to the artists for completion prior to placing on film. *

* All illustrations and exercise boards were prepared by the USASCS.

g. Display Material - The authors decided upon the format for a particular display and then transcribed their material from the text or answer analysis forms to the Display Planning Guide form. To display material on the CRT, a set of coordinates which specify the area and position on the screen for a display must be defined. Since the Display planning Guide form is made up of rows and columns, the programming group used these forms to assign the proper coordinates as determined by where the authors had placed their material (Figure A-13).

A.5 COMPUTER IMPLEMENTATION

Implementation was divided into four stages: programming, key-punching, assembling, and debugging. The first two were concerned with the preparation of material for the computer, and the last two with the operation of the material while on the computer.

a. Programming - Programming consisted of two tasks, program design and coding. In program design, methods were devised to handle the course logic framework.

   This included requirements for:

   1. Forming the structure of each element in the course organization.
   2. Specifying procedures for transition from one element to another.
   3. Generating logic to control student progress and presentation.
   4. Evaluating logic for pretest and lesson test.
   5. Presenting instructional effects, such as blinking words, clearing screen between frames, etc.
   6. Specifying general logic requirements such as timing questions, use of glossary, setting up computer system, etc.

   In the coding task, material was converted to the Coursewriter II programming language. Three subtasks were included in this phase. First, the written course material on the Display Planning Guide forms was coded. Second, the graphics and special symbols were formed and coded. Third, the logic specified by the program design was coded.

IBM 1510 Instructional Display Planning Guide

BO338 A

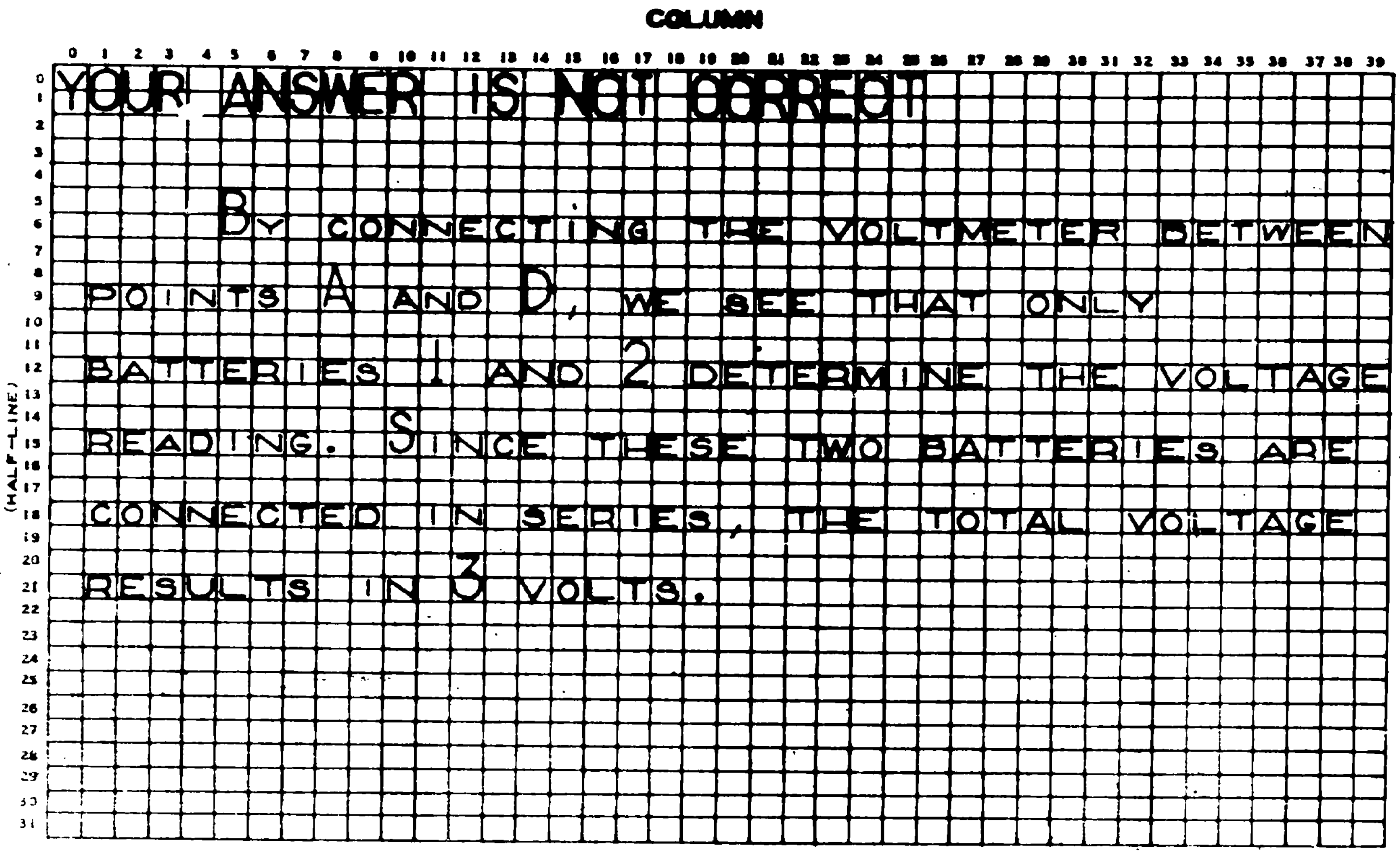


Figure A-13. Instructional Display Planning Guide

Macros were created to reduce the amount of coding. A macro is a skeleton of coding unit. The programmer inserted variables into a macro and then used it as if he had done all the coding. An example of macro usage is blinking words. When this effect was desired, a single line of coding called forth the macro. The macro coding was then automatically filled in. Without a macro the programmer would have had to code the eight lines separately.

b. Keypunching - Instructions on the coding sheets were punched one to a card by an operator. When a lesson had been completely punched, its logic, course writing, and macros were merged to form an individual deck of cards. The lesson was then ready for assembling.

c. Assembling - Each lesson was loaded and run on the computer. During the assembly, the computer checked the program for errors and, upon finding any, listed them.

d. Debugging - The programmer had those cards with the listed errors repunched. He then reviewed the lesson for general logic bugs. These were corrected and the lesson reassembled. After three iterations of the above, the lesson was turned over to the author for the review and revision phase.

A more comprehensive description of the implementation methodology and computer operation may be found in the final portion of this appendix.

A.6 REVIEW AND REVISION

After the lesson was implemented on-line review of this material was initiated. Three additional forms were created:

a. Lesson Review Form (Figure A-14)
b. Change Form (Figure A-15)
c. Comment Sheet (Figure A-16).

The on-line review process is divided into two stages. In the first, or Pre-Student stage, authors reviewed their material to determine whether the content and logic were what they had intended. Concurrently, other

LESSON REVIEW FORM

Lesson Title

Series Battery Connection

Reviewer

AEN

Lesson Time (First Time Through)

36 minutes

Comments

1. The explanation offered on problem 3 of the lesson test is not clear.

2. There ought to be more illustrated examples on the series opposing connections.

3. The instruction on topics voltage, current, and capacity were well done.

Figure A-14. Lesson Review Form

CHANGE FORM

I. General - Type of Change

A. Timing: Frame Number ______ How Long ______

B. Test : New Frame Number B03390

C. Slide : New Slide Number ______

D. Any other: Comment ______

II. Text - Type of Change

A. Add: After Frame Number ______

B. Delete: Frame Number ______

C. Replace: Frame Number B0338A

Segment Number 4

Lesson Number 3

Review Date 10/11/67

Implementation Date 10/20/67

Figure A-15. Change Form

COMMENT SHEET

Lesson Title

Series Battery Connections

General Comments

"Everywhere" spelled incorrectly in BØ319E-12

Add after BØ324-1 fpØ

Change BØ319E-14 to
dt 13, 1 1 1 1 through an electrical device

Insert after BØ321B-4
fpØ 543

Figure A-16. Comment Sheet

project personnel reviewed the material for technical and grammatical correctness. In the second stage, sample students took portions of the course and authors studied the students' performance recordings for possible course material revision.

A. 6. 1 First Stage General Review Procedure

a. Authors reviewed each lesson on the computer by comparing the screen presentation with the corresponding display guide page. Upon encountering an area where a change was desired, they completed the Change Form and where necessary generated a new display guide sheet. These were then turned over to programming for implementation.

b. All other people reviewing lesson material followed this procedure:

   1. Took lesson instruction in one complete pass and filled out Lesson Review Form
   2. Reviewed lesson material frame by frame and filled out Comment Sheet, if necessary, and turned them over to the author. The author then revised his material accordingly.

A. 6. 2 Second Stage Review Procedures

Sample students took the course. At the end of each lesson, they were asked to fill out the Comment Sheets. When completed, these forms along with the performance recording data provided the basis for revisions.

Student Performance Recording (Figure A-17) is an optional feature which, when requested by an author, has the 1500 Instructional System automatically write a record (either on tape or disk) containing items specified by the author for every student response (Figure A-18). These records used to determine whether or not questions were answered correctly, record actual responses, response time, and other information to provide a complete picture of student activity. By evaluating these performance records, the author is able to pinpoint common areas of student difficulty. He can take action to enhance the instruction in those areas (Figure A-19).

Record Number 12 Course Name-Sample Student Number S001

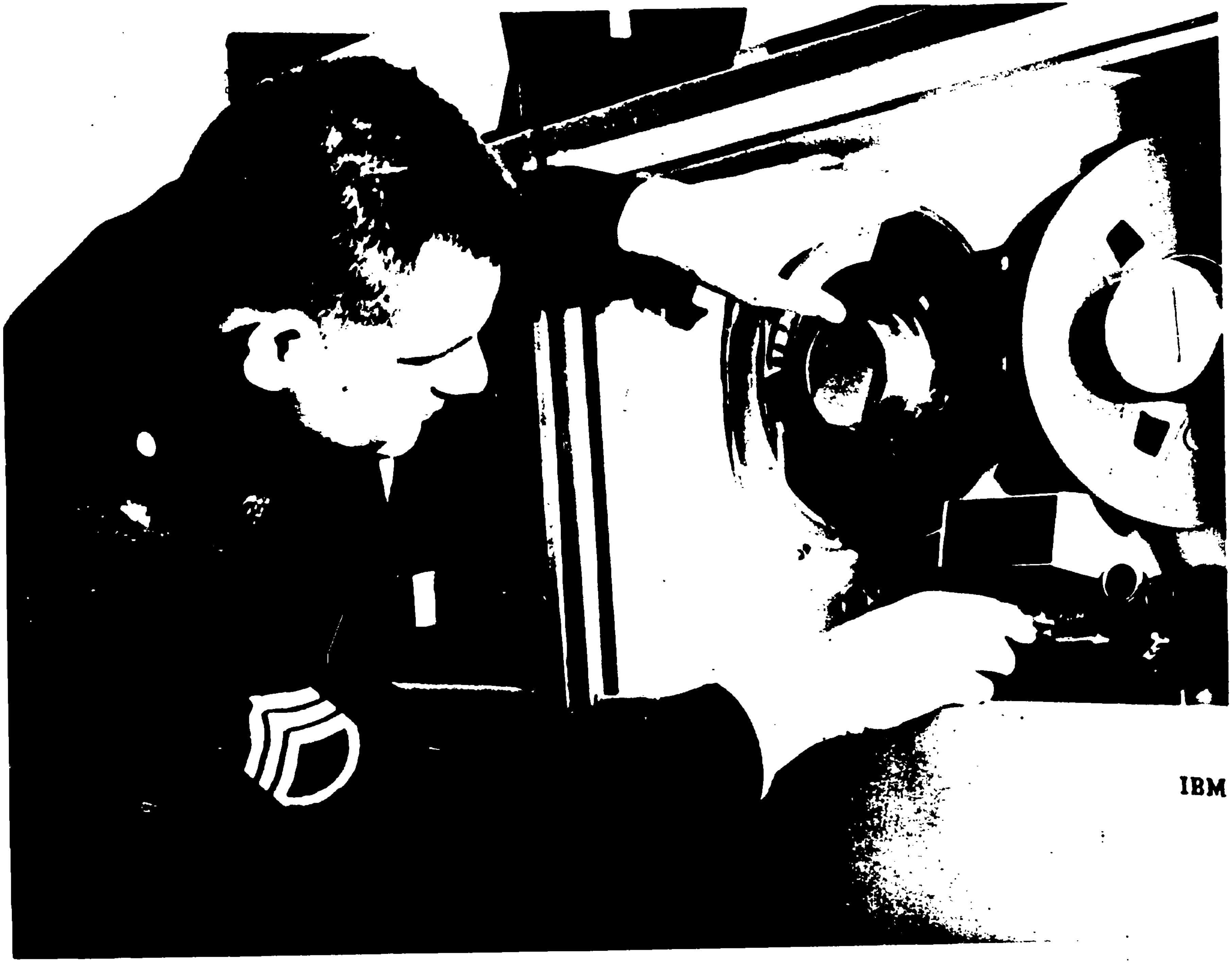
Time of Recording 01'38 **Response ID** 002027IP

Match ID **CI** **Latency Time** 0025.2 seconds

Student Answer 12 **Characters** - Resistance AM Date 12-05-67

C01	**1**	**C02**	23	C03	C04	C05	C06
C07		**C08**		C09	C10	C11	C12
C13		**C14**		C15	C16	C17	C18
C19		**C20**		C21	C22	C23-112	C24
C25		**C26**		C27	C28	C29	C30

Figure A-17. Sample Student Performance Recording



IBM

Figure A-18. Student's Performance Is Recorded on Tape

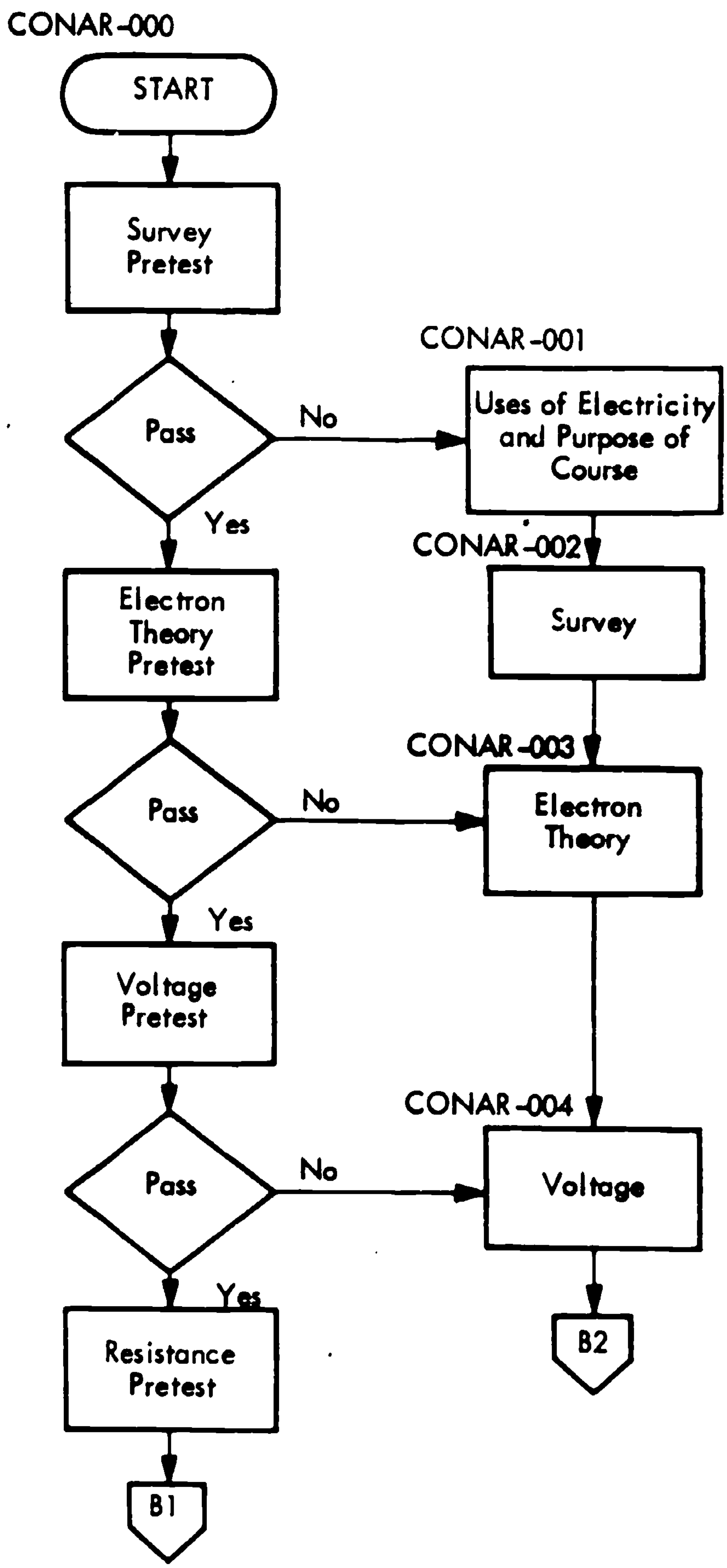


Figure A-19. USCONARC Course Flowchart (Sheet 1 of 5)

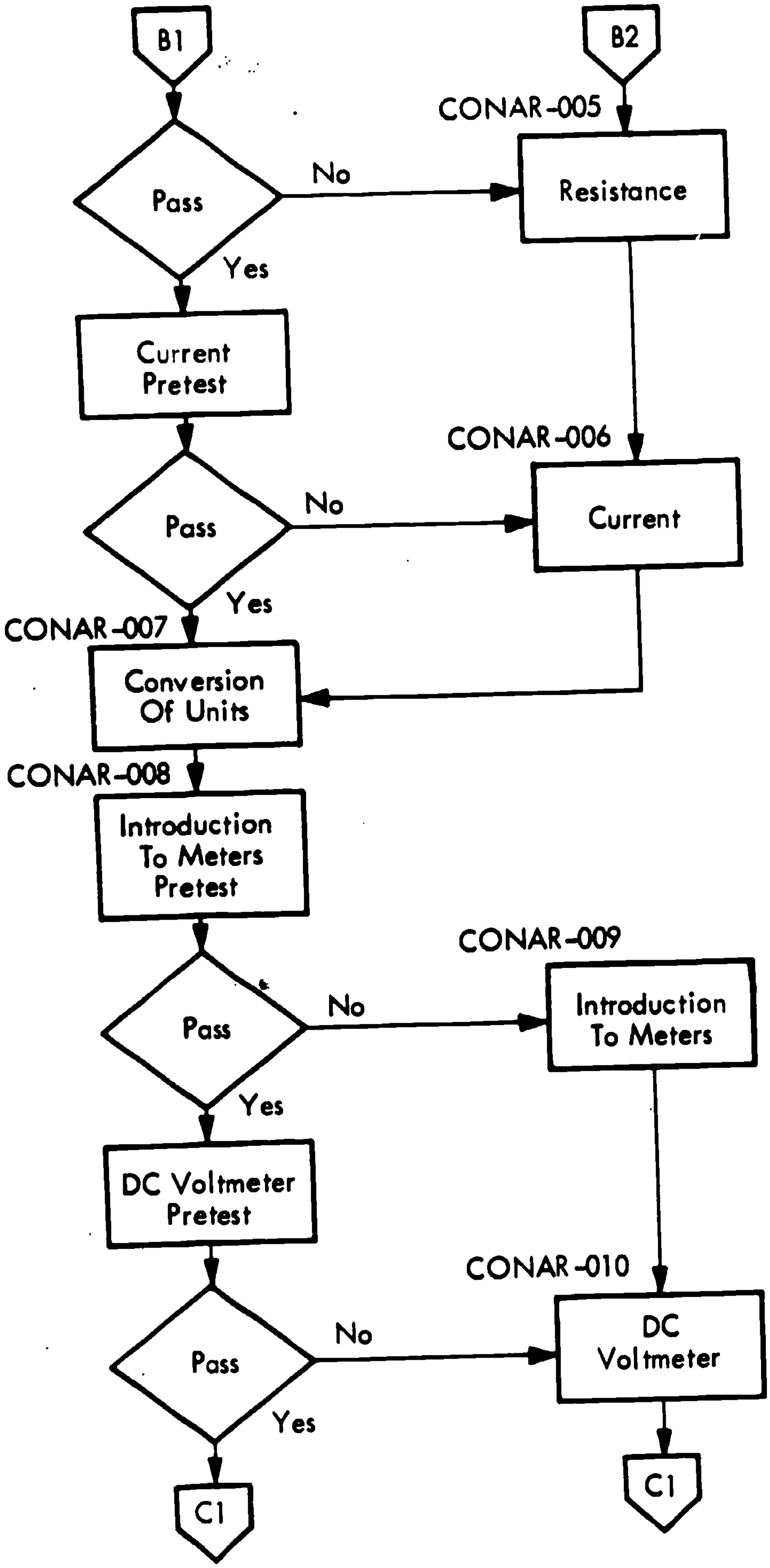


Figure A-19. USCONARC Course Flowchart (Sheet 2 of 5)

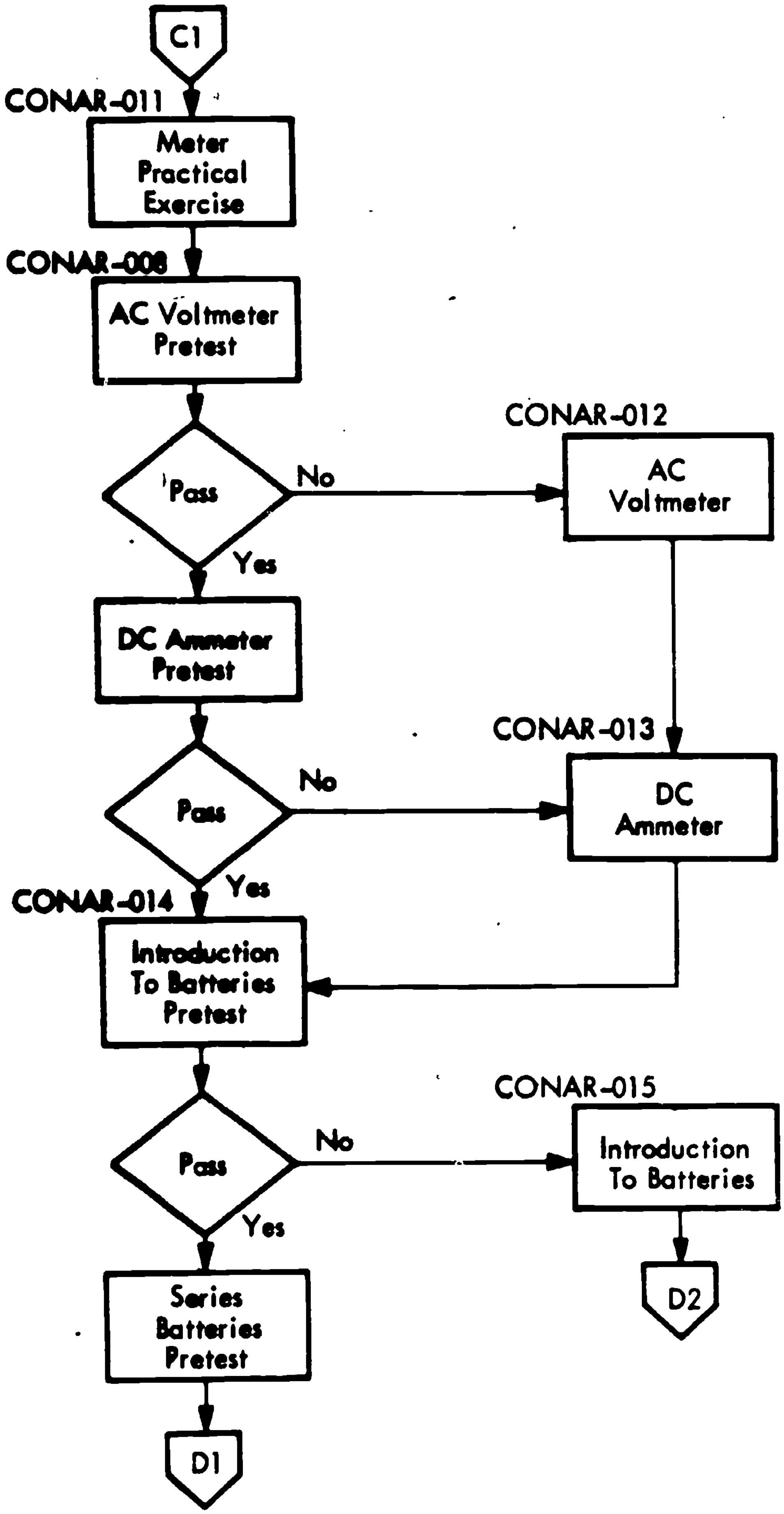


Figure A-19. USCONARC Course Flowchart (Sheet 3 of 5)

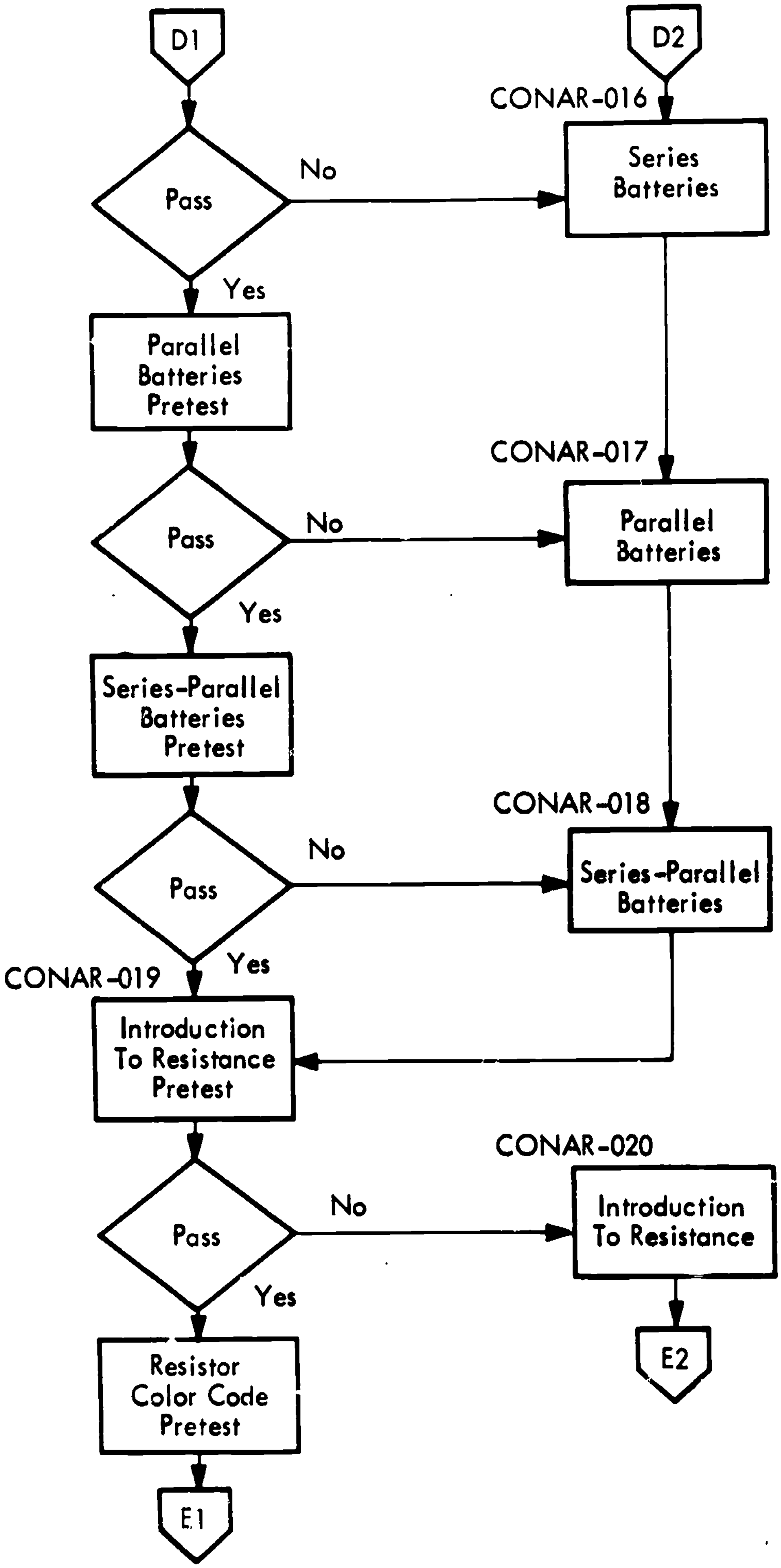


Figure A-19. USCONARC Course Flowchart (Sheet 4 of 5)

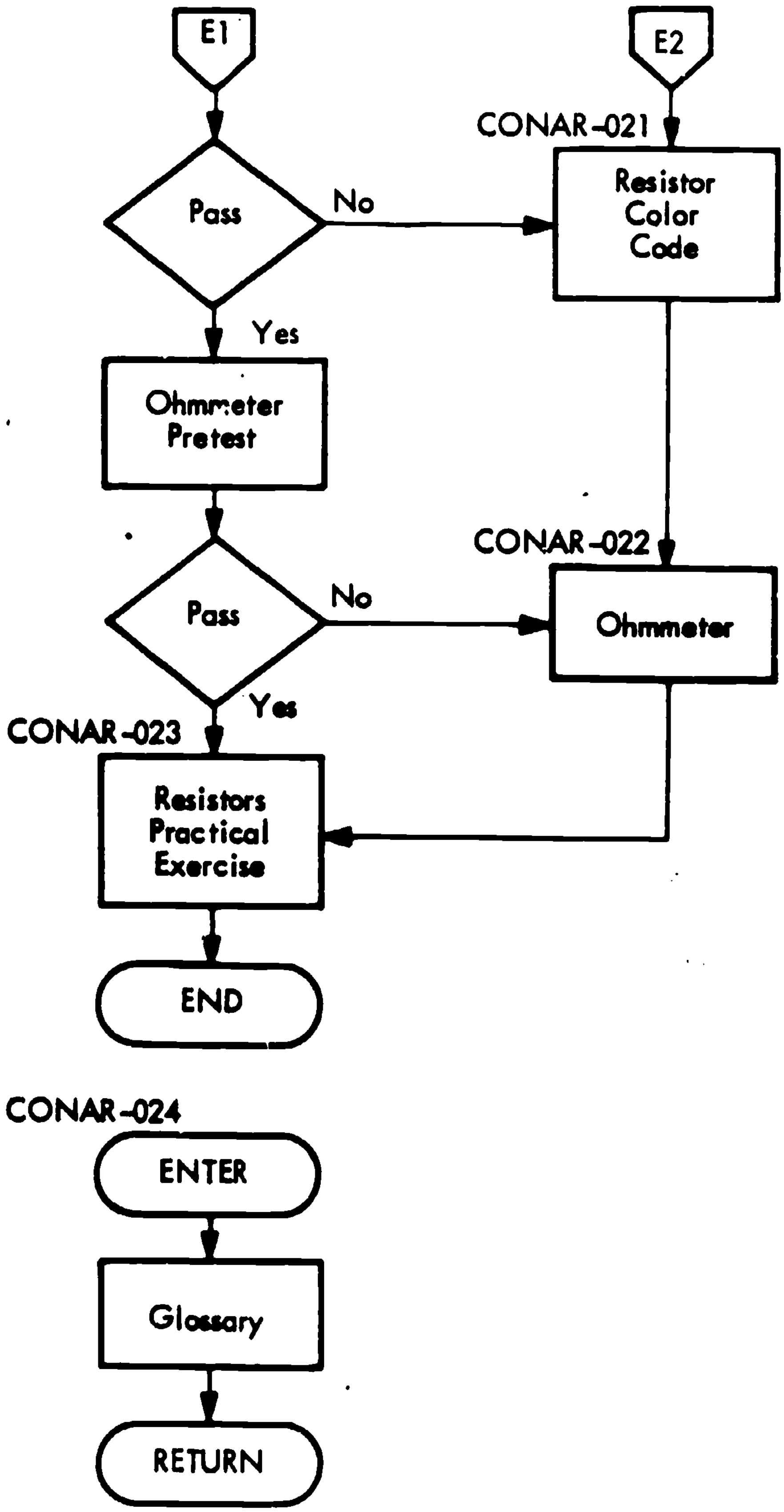


Figure A-19. USCONARC Course Flowchart (Sheet 5 of 5)

The 1500 Instructional System writes performance records, requested by an author at the time a student is registered for a course. A performance record is written for each response entered by a student. All items contained in the record are optional and may include:

a. Student number
b. Name of course
c. Clock time of recording (used to determine the length of time taken between questions)
d. Latency time (time required to complete a response)
e. Response identifier (to distinquish among responses)
f. Actual student response
g. Match identifier (right or wrong)
h. Contents of any counters and switches used by the author to record special information
i. Other relevant material.

Figure A-17 is an example of a student Performance Record.

During instruction the function of the glossary was to provide the student with a definition or explanation of a requested term. Since most questions had this feature, it was employed by the author and reviewer to indicate a specific problem area (material too difficult, incorrect, not clear, etc.) without disturbing the course logic flow. The glossary was not available during review. Each time the glossary option was chosen, a performance recording was generated and the program requested another response to the question. By examining the performance recording listing, an author and reviewer could pinpoint the problem areas and refer to the appropriate course material for possible revision (Figure A-20).

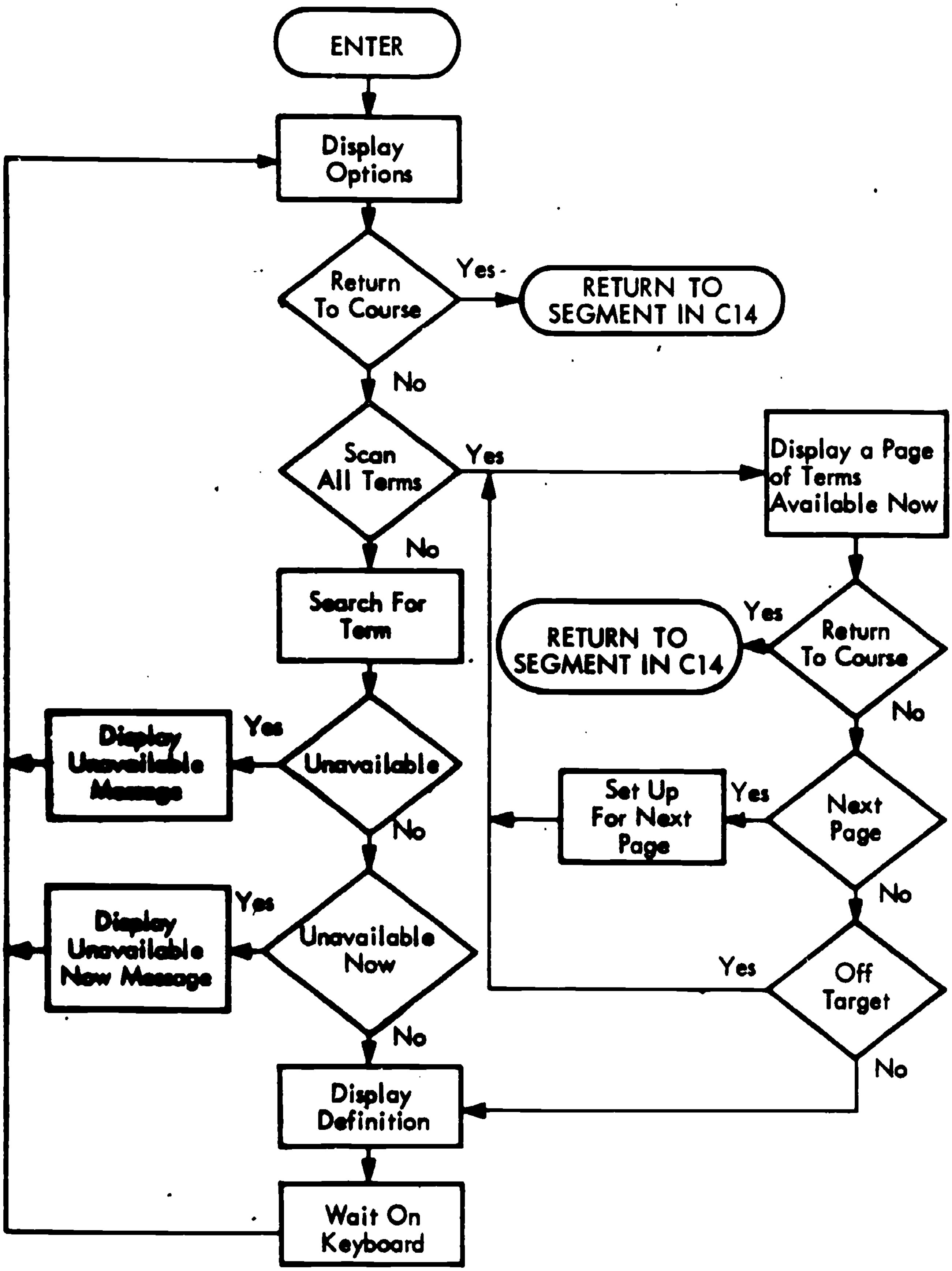


Figure A-20. Glossary Routine Flowchart

A.7 COURSE DOCUMENTATION

A.7.1 Course Description

a. List of Segments

The USCONARC course is named CONAR. It consists of 24 Coursewriter II segments. The list below describes the content of each such segment:

SEGMENT NUMBER	DESCRIPTION
0	Introduction Unit Pretest
1	Uses of Electricity and Purpose of Course
2	Survey of Electricity
3	Electron Theory
4	Voltage
5	Resistance
6	Current
7	Conversion of Units
8	Meters Unit Pretest
9	Introduction to Meters
10	DC Voltmeter
11	Meter Practical Exercise
12	AC Voltmeter
13	DC Ammeter
14	Batteries Unit Pretest
15	Introduction to Batteries
16	Series Batteries
17	Parallel Batteries
18	Series - Parallel Batteries
19	Resistors Unit Pretest
20	Introduction to Resistance
21	Resistor Color Code
22	Ohmmeter
23	Resistors Practical Exercise
24	Glossary

b. Unit Structure

The course is divided into four logical units: Introduction, Meters, Batteries, Resistors. Each unit is started with a pretest, which determines if a student may skip one or more lessons in that unit. Figure A-17 shows the details of course flow.

c. Lesson Structure

Instructional lessons consist of instructional problems and lesson test problems. Figure A-5 shows this instructional lesson logic.

Practical exercises have no summary or test.

d. Pretest Structure

The course contains a set of pretest problems for each lesson that a student may skip. A student fails a pretest when he exceeds the allowed number wrong for that lesson. The limits are:

NUMBER OF PROBLEMS ON LESSON PRETEST	ALLOWABLE NUMBER WRONG
1-4	0
5-9	1
10-13	2
14-	3

When a student exceeds the allowed number wrong, he is given no further pretest problems for that lesson but is sent to the instructional material (Figure A-17).

e. Use of Switches, Counters, Return Registers

The course uses switches:	S1-S25
The course uses counters:	C1-C14
	C20-C22

The course uses return registers: RR1, RR2

f. Description of Identifiers, Labels

The following conventions were used in most of the USCONARC course material. Exceptions do exist. This information is useful in interpreting performance records.

1. EP Identifiers - EP identifiers are 10 characters long and coded as follows:

CHARACTER NO.	DESCRIPTION
1-2	00-Introduction
	01-Meters
	02-Batteries
	03-Resistors
	04-Conversion of Units

3-5	Lesson Number
6-8	Problem Number
9-10	IP-Instructional Problem LT-Lesson Test Problem PT-Pretest Problem PE-Practical Exercise Problem

Match Identifiers - Match Identifiers are two characters long and coded as follows:

CX*	Correct Answer
WX*	Wrong Answer
UI	Unrecognizable Answer
GI	Glossary Request
UP	Light Pen Response-Missed target
CS	Correct Answer - Spelling error

*NOTE: X is some numeric or alphabetic character

Labels - Labels are six characters long and coded as follows:

CHARACTER NUMBER	MEANING
1	I Introduction M Meters B Batteries R Resistors
2-3	Lesson Number
4-6	Frame Number

Labels in the pretest and practical exercise segments do not follow this convention.

g. Glossary

Segment 24 in the course is the glossary (Figure A-21). The glossary is accessed in a closed subroutine by the student for instructional problems as follows:

1. On multiple-choice problems (light pen) by pointing to the "Glossary" choice.

2. On fill-in (keyboard) problems by keying "GLOS".

Once in the glossary, the student may ask for the definition of a term by keying it in, scan all available glossary terms, and point to the one he wants defined, or he may return to the course. The glossary contains 38 terms. At the beginning of the course, the glossary is empty. As the student proceeds through the course, glossary terms are "added" by setting switches to 1 in course-writer counters C20, C21 and C22. One switch is used for each term.

Counter 14 and return register 2 are used by the glossary routine to return to the proper problem in course segment. Each lesson initializes counter C14 to hold its segment number and initializes return register 2 to hold the label heading the current problem. The glossary routine executes a transfer instruction to return to the beginning of the current course segment. The first executable instruction in the segment is a branch to return register 2 (BR, RR2); this returns control to the current problem in the course.

Glossary calls function LD, which was written to minimize response time in the scan option of the routine.

The list of glossary terms contains the label of the frame in the course in which the term is introduced and the switch number used to determine the term availability.

GLOSSARY TERMS

NO.	TERM	FRAME	SWITCH
1	Absolute Tolerance	R0217	20A
2	AC Voltage Procedure	M0307	20B
3	Ampere	I0324	20C
4	Ampere Hour	B0237	20D
5	Applied Voltage	I0629	20E
6	Capacity	B0235	20F
7	Color Code	R0201	20G
8	Conductance	I0647	20H
9	Conductor	I0306	20I
10	Current	I0 321	20J
11	DC Current Procedure	M0501A	20K
12	DC Voltage Procedure	M0266	20L
13	Electrode	B0206	200
14	Electrolyte	B0206	20M
15	Electromotive Force	I0509	20N
16	Function Switch	M103	20P
17	Input Jacks	M103	21A
18	Insulator	I0444	21B
19	Internal Resistance	B0226	21C
20	Meter Face	M103	21E
21	Meter Plugs	M131	21D
22	Ohm	I0318	21F
23	Ohms Zero Adj.	M115	21G
24	Parallel Battery	B0402	21H
25	Primary Cell	B0215	21I
26	Probes	M131	21J
27	Range Switch	M115	21K
28	Resistance	I0314	21M
29	Resistor	I0611	21L
30	Secondary Cell	B0216	21N
31	Series Battery	B0305	21O
32	Series Opposing Battery	B0328	21P
33	Series-Parallel Battery	B0602	22A
34	Test Leads	M131	22B
35	Tolerance	R0217	22C
36	Volt	I0304	22D
37	Voltage	I0301	22E
38	Voltage Drop	I0630	22F

Figure A-21. Glossary Terms

A.7.2 Machine Requirements

The course requires three disk drives, one for the system pack and the other two for course packs. If performance recording is desired, either one additional disk drive or a magnetic tape unit (available on 1500/1800 only) is required. The course requires student stations consisting of a 1510 CRT/Keyboard and 1512 film projector. The film cartridges are usable only on 1512 Model A units. It is suggested that 1518 typewriter be assigned as a proctor station while the course is being administered.

A.7.3 Procedure for Building the Course

a. Initialize disk packs 00000
   00001
   00100
   00101

b. Configure system pack (00000) from master pack (32767)

c. Replace system dictionary (SYSDC01) from cards

d. Load graphic set CONAR01 from cards

e. Load coursewriter functions from cards

f. Load coursewriter macros from cards

g. Register author H001

h. Register course segments CONAR-00 through CONAR-13 on pack 00100

i. Assemble course segments CONAR-00 through CONAR-24 from cards

j. List course segments on printer (optional)

k. Catalog course

l. The course is now ready for a student session.

A.7.4 List of Card Decks

a. Disk pack Initilization Cards

b. System Configuration/Reconfiguration Cards

c. System Dictionary - SYSDC01

d. Coursewriter Functions

1. LD
2. LT
3. ED

e. Graphic Set - CONAR01

f. Coursewriter Macros

1. MBH001
2. MCH001
3. MDH001
4. MFH001
5. MGH001
6. MHH001
7. MRH001
8. MSH001
9. MTH001
10. MUH001
11. MWH001
12. MXH001
13. MZH001
14. ESH001
15. ETH001
16. MER001
17. MER002
18. PTR001

g. Course Decks CONAR-00 through CONAR-24

h. LSTCSE Cards CONAR-00 through CONAR-24

i. PERFOR Cards for Students S050-S055
S060-S065
S070-S075

A.7.5 Operational Procedures During Course Administration

a. Procedure for Starting the 1500 System

1. Press ON at CPU

2. Turn on 1510's, 1512's, 1518's

BEST COPY AVAILABLE

3. Mount disk packs

   a. Pack 00000 on Drive 0
   b. Pack 00100 on Drive 1
   c. Pack 00101 on Drive 2

4. Wait for Disk READY lights

5. On CPU press:

   a. IMMED STOP
   b. RESET

6. Load Coldstart Deck (3 cards) into reader.

7. Press PROG LOAD on CPU

8. Mount daily performance tape containing tape ring on 2402 Drive 1

   a. Thread tape past tape mark
   b. Press RESET
   c. Press LOAD REWIND
   d. Press START

9. Sign on typewriter as proctor

b. Procedure in Initializing the 1500 System for a Student Session

1. Start the 1500 System (steps 1-9 above)

2. At proctor station: type

   a. assign 6; All
   b. date 11/16/67
   c. clock 8:12
   d. register (0) conar/sØØ1, , 111111
   e. perform T, 1
   f. latency 9999

3. Load film into 1512's

4. At proctor station

   a. id fØ
   b. id f1
   c. id f3

5. Sign students on conar-000/s∅∅1, , 1

c. Procedure for Shutdown of 1500 System

1. Sign all students off

2. At proctor station:

   a. Perform u, 1 (Writes End-of-File)
   b. Off

3. Dismount Perform tape

   a. Press RESET
   b. Press LOAD REWIND
   c. Press UNLOAD
   d. Unthread tape

4. On CPU press:

   a. IMMED STOP
   b. RESET

5. Press STOP on each disk drive

6. When UNLOCK lights come on, dismount disks

7. Unload film from 1512's

8. Turn all 1510's and 1518's off

9. Remove cards from reader, press NPRO

10. Press OFF at CPU

d. Procedure for Listing Performance Tape

1. Start system (steps 1-5 above)
   Only disk pack required is Pack 00000

2. Be sure that End-of-File Mark has been written on tape

3. On reader press NPRO

4. Load Perfor Deck into reader

5. Load 3-part paper into 1443

6. Press READY on 1443

7. At proctor station: schedule perfor

8. Performance tape will now be listed

9. At end of job shutdown 1500 (see shutdown, above - Do not do step 2a)

e. Procedure for Restarting 1500 System

1. On CPU press:

   a. IMMED STOP
   b. RESET

2. Check POWER ON

3. Check disks ready

4. Check tape ready

5. On reader press NPRO

6. Load Restart Deck into reader

7. Press PROG LOAD on CPU

8. Students will now be restarted; proctor will still be signed on

9. Note trouble in log

10. If hardware errors persist, call customer engineer.

APPENDIX B

PROCTOR INSTRUCTIONS

B.1 EQUIPMENT OPERATION

a. Start-up procedure

IBM personnel will make all preliminary preparations regarding initialization of the COURSE WRITER operating system (mounting of disk packs, tapes, film strips, etc.).

IBM personnel will set up each student station. Each typewriter will be placed under the table (behind the student as he faces the CRT). Each typewriter will be turned off. Each image projector will be moved close to the CRT. (See photograph attached to Appendix A.)

b. Student sign on/sign off

Students will be given a card containing their name, student number, and the CAI course identifier on Wednesday evening. This card will also contain the regularly scheduled appointment times, the sign on procedure, and the sign off procedure. (See Sample Student Card.) A copy of the above information will be attached to these instructions (Student Registration Form).

Students will be expected to execute the sign on/sign off procedures as those procedures are required or requested. Students will be told that they must:

1. Sign off before leaving the terminal unattended

2. Sign off for rest breaks <u>only</u> between Lessons (<u>not</u> within lessons) - emergency situations excepted

3. Sign on and continue working immediately after returning to the terminal.

When the student completes the course (resistors practical exercise is last) he should be given the opportunity to take a break before taking the criterion test.

The criterion test will be administered in the terminal room with the student located away from those still working on the course material. (See Addendum F.)

c. Shutdown Procedure

IBM personnel will be responsible for turning off the equipment and policing the appropriate areas after all students have completed their designated day's work. Prior to equipment shutdown, IBM personnel will:

1. Verify that all students have been signed off

2. Remove and account for all film cartridges

3. Turn off all CRT's, typewriters, and film projectors

4. Copy the response tape

5. Remove all USCONARC materials from the machine

6. Shutdown the machine.

d. Equipment malfunction procedure

If a student reports an apparent malfunction the proctor will:

1. Note the time of the initial report

2. Investigate the report

3. Notify IBM personnel if, in fact, a malfunction exists

4. Ask the student to take a break (and leave the area)

5. Ascertain the student's location in the course.

IBM personnel (one only) will:

1. Verify that the student has been signed off

2. Attempt to correct the malfunction.

3. If the malfunction cannot be readily corrected,

   (a) Shut down the student station

   (b) Leave the area immediately

   (c) Make necessary arrangements to restore the student station as soon as possible

   (d) Complete a comprehensive report describing the failure.

B.2 Assistance to Students during the Experiment

a. The proctor will be familiar with the special instructions provided for each segment.

   1. Introduction (see Addendum A)

   2. Multimeter (see Addendum B)

   3. Batteries (see Addendum C)

   4. Resistors (see Addendum D).

b. The proctor will assist the students in completing the course in manner which will result in minimal interference with the instructional environment.

c. If the student has a problem, the proctor will:

   1. Verify that the student has read all relevant material

   2. Check to see if the difficulty is merely a typing problem

   3. Answer student questions as clearly as possible but without volunteering information.

d. The proctor will note each action taken relating to the student, including (see Addendum E):

1. Student identification

2. Location within the course material

3. Nature of request

4. Nature of action taken

5. Elapsed time involved.

e. The proctor will note all unusual activity which does not result in communication with the student. (See example of Proctor Call.)

B. 3 Test Administration

a. The proctor will

1. Ask the student to sign off if sign off did not take place automatically

2. Give the student an opportunity to take a break (10 minutes maximum)

3. Administer the test in the terminal room with the student located away from those still working with the course material.

b. Attitude questionnaires may be administered after the student has completed the criterion test.

SAMPLE STUDENT CARD

NAME

Your Student Number is 5075

You Are Taking CONAR on Station 1
(Course Name)

Your Appointment Times are:

Date	Day	Time
11/23	Thurs	8-12 A.M.
11/23	Thurs	4-8 P.M

TO SIGN ON:

1. Depress the ALTN CODE and INDEX keys at the same time.
2. Type
   "on CONAR ."
3. Signal enter (ALTN CODE and space bar)

TO SIGN OFF:

1. Depress the ALTN CODE and INDEX keys at the same time.
2. Type
   "OFF"
3. Signal enter

STUDENT REGISTRATION FORM

STUDENT			APPOINTMENT TIMES			
			Thursday		Friday	
Number	Name	Station	am	pm	am	pm
S070		2	8-12	4-8		
S071		2		12-4, 8-12		
S072		3	8-12	4-8		
S073		3		12-4, 8-12		
S074		1	8-12	4-8		
S075		1		12-4, 8-12		

ADDENDUM A

Proctor Instructions - Introduction Segment

a. Provide pencil, eraser, ash tray, and paper.

b. Provide student with exercise board of simple circuit with batteries on left-hand side and rheostat on right: set rheostat knob so contact is midway between end points and open switch.

When student has completed Introduction segment and begins Meters segment, remove board, open switch, and loosen one conductor.

ADDENDUM B

Proctor Instructions - Multimeter Segment

a. The proctor will provide paper, pencil, clean ash tray, and eraser to the student and encourage him to make free use of them.

b. The proctor will set up one multimeter and one set of batteries in the area adjacent to the film strip projector:

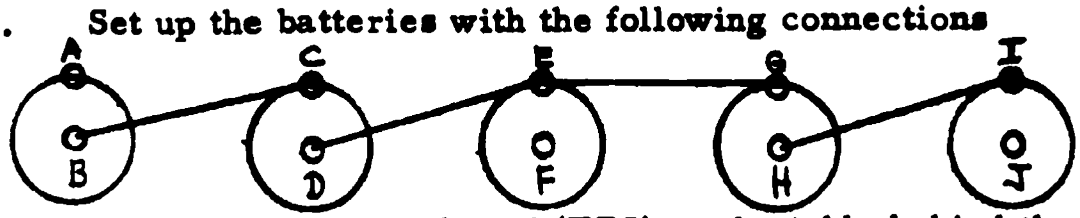
1. Set the meter function switch to 20,000 ohms/v DIRECT

2. Settings of the zero ohms adjust and range switches are not critical

3. Connect the red lead to the 50V jack on the left side of the meter

4. Connect the black lead to the common jack

5. Set up the batteries with the following connections



6. Place the exercise board (EB2) on the table behind the student - unplugged and with fuses removed.

c. When the student has completed the practical exercise, remove the batteries from the station area.

ADDENDUM C

Proctor Instructions - Battery Segment

The proctor will provide paper, pencil, clean ash tray, and eraser to the student and encourage him to make free use of them.

ADDENDUM D

Proctor Instructions - Resistors Segment

a. The proctor will check to see that the student has a sufficient supply of paper, pencils, clean ash tray, and erasers.

b. The proctor will supply the student with:

   a. The color slide and encourage him to use it because of poor color reproduction on the slide

   b. The "work sheet" (copy attached) as it is required in the practical exercise

c. The proctor will remove the batteries from the immediate area.

d. Place the exercise board on the table beside the meter

e. If a student receives the message:

   You missed it again
   Call the Proctor

   The proctor will assist the student in measuring the resistor in question. The student will then type in the value obtained. (If he is wrong again, the system will provide the correct answer.)

WORK SHEET

RESISTOR	I. VALUE	II. UPPER LIMIT	III. LOWER LIMIT
1			
2			
3			
4			
5			
6			
7			
8			
9			
10			

WORK SHEET

RESISTOR	I. VALUE	II. UPPER LIMIT	III. LOWER LIMIT
1	1.5	1.65	1.35
2	27	28.35	25.65
3	1,200	1,320	1,080
4	270	283.5	256.5
5	39,000	42,900	35,100
6	33,000	34,650	31,000
7	560	616	504
8	18,000	18,900	17,100
9	4,700	5,170	4,230
10	1,500,000	1,650,000	1,350,000

ADDENDUM E

PROCTOR CALL

Date/ Time	Student Station	Student ID	Course Location	Nature of Request	Proctor's Comment or Action	Proctor's ID	No. of Students Making This Request

ADDENDUM F

Criterion Test Administration Procedures

1. Give student(s) answer sheet, ash tray, pencil, test booklet
2. Student will print last name, first name, middle initial
3. Write date
4. Test Identification is CTI (pretest) or CTII (post test) and test booklet number
5. Student ID is his Army Serial Number. (It is not necessary for him to mark sense area.)
6. Student should write over cols. 1-4, A, B, C, D, on each column of answers
7. Tell student - 85 items, 4 alternatives, multiple choice
8. Show students pictures on page 15 and page 16
9. Tell student - attempt every item, no penalty for guessing
10. Tell student - select BEST answer to questions
11. Tell student - do not mark on test booklet
12. Put start and stop times on answer sheet
13. Supply student with multimeter TS/352-U (as in Addendum B)
14. No time limit.

APPENDIX C

COST ANALYSIS

C.1 CAI COSTS

The cost data presented in this analysis includes estimates, since the available cost data in many instances does not provide directly applicable information. In many areas the available data had to be interpreted, extrapolated, and recomputed to provide usable data. There are no available data for some cost categories; in some cases, the costs are included in other categories and cannot be identified or separated. This introduces inconsistencies in the cost data presented and should be so recognized.

These data are presented primarily to illustrate the analysis methodology and provide an overview of cost relationships. Readers are invited to recompute or refine the cost data where there is disagreement based on their own criteria. Three alternatives are presented.

C.2 COST OF CAI SYSTEM (ALTERNATIVE 1)

The general procedure for determining costs of the CAI system was to identify all costs germane to the installation and operation of an IBM 1500 Instructional System at U. S. Army Signal Center and School (USASCS). These cumulative costs were distributed in accordance with consistent logical methods to arrive at a representative cost of a CAI hour. This cost factor can then be multiplied by the appropriate number of instructional hours to compute course costs. This provides a useful unit of cost to determine representative CAI cost of multiple situations.

C.2.1 CAI Cost Model

The costs of a proposed IBM 1500 CAI system for USASCS can be grouped into two general classifications: capital investment costs and continuing costs. The different computational procedures required for determining instruction hour costs and the time of cost accrual logically fit into two general classifications.

C.2.2 CAI Capital Investment Costs

CAI capital investment costs for the IBM 1500 Instructional System are further divided into three categories of related costs: hardware, installation, and facilities These include all those items required to provide a CAI system ready for use. Specifically, the hardware cost category includes all manufactured items of the CAI system such as the central processing unit, instructional displays, attachments, controls, and associated equipment. The installation cost category includes such items as equipment connectors, cabling, false flooring, and other items germane to the installation of an IBM 1500 Instructional System at USASCS. The facilities category includes the cost of new buildings or renovation of existing buildings required to house the CAI system.

Capital investment costs are assets that, in effect, are a collection of potential services that will be expended over the following months and years. The CAI system, for example, can provide many hours of course material instruction for many individuals over a number of years. This service can be provided at a relatively uniform rate throughout the useful life of the system. It seems logical to distribute the costs of the system uniformly to its users over the system's expected useful life.

The useful life or depreciation schedule will have a major impact on the cost per instruction hour and ultimately on the cost of producing graduates. An accepted practice in the business community is to depreciate data processing equipment over a four to five year period. This is done by profit-seeking organizations to achieve a fast write-off of capital outlays to expense for obvious tax advantages and as a hedge against obsolescence. Are these reasons appropriate to select a four to five year depreciation schedule for the IBM 1500 at USASCS? Kopstein and Seidel (1967) suggest a 10-year depreciation period as more appropriate for CAI system hardware. CAI costs based on depreciation schedules for both five year and ten year periods are provided here (Table C-1).

C.2.3 CAI Continuing Costs

This classification of costs include those recurring costs that accrue with the passage of time and generally require outlays of funds periodically.

Table C-1

CAI CAPITAL INVESTMENT COSTS

IBM 1500 SYSTEM

Hardware		Purchase: 24 Terminal Sys.	Purchase: 32 Terminal Sys.	Rental: 24 Terminal Sys. (Mo. Costs)	Rental: 32 Terminal Sys. (Mo. Costs)
1131	Central Processing and Attachments	$111,275	$111,275	$ 2,586	$ 2,586
1132	Printer	11,350	11,350	268	268
1133	Multiplex Control + Disk Controls	16,875	16,875	375	375
1442	Card Read Punch	14,575	14,575	265	265
2310	Disk Drive	31,725	31,725	705	705
2315	Disk Cartridge	360	360	---	---
1502	Station Control and Adapters	72,090	77,440	1,655	1,780
1510	Instructional Display	67,440	89,920	1,848	2,464
1505	Audio Adapter and Drive	92,080	122,430	2,346	3,120
1512	Image Projector	85,440	113,920	2,160	2,880
1518	Typewriter	6,260	6,260	180	180
029	Keypunch	12,750	12,750	243	243
2415	Tapedrive and Control	44,500	44,500	910	910
RPQ	FXXX Mat. Tape Attachment	*25,000	*25,000	*500	*500
	TOTAL	$591,720	$678,380	$14,041	$16,276
				**519	**519
				$14,560	$16,795

* Estimated

** Monthly availability charges (rental) covers the operational use time for metered units of the system for 176 hours per month per metered unit. Operational use above and beyond this time is subject to "Extra Use Charges".

Note: Prices quoted herein are those currently in effect and are subject to change as provided in the IBM/GSA Federal Supply Schedule.

Table C-1 (Continued)

	Purchase		Rental	
	24 Terminal Sys.	32 Terminal Sys.	24 Terminal Sys.	32 Terminal Sys.
Monthly Costs				
Depreciated 5 yrs. Straight-Line	$9,862	$11,306	$14,041**	$16,276**
Depreciated 10 yrs. Straight-Line	4,931	5,653	14,560* **	16,795* **
Instructional Hour Costs Based on System Use				
6 hr./day use (5 yr. dep.)	$3.16	$2.71	$4.49	$3.91
(10yr. dep.)	1.58	1.36	4.49	3.91
12 hr/day use (5yr. dep.)	1.58	1.36	2.33	2.02
(10yr. dep.)	.79	.68	2.33	2.02
18 hr/day use (5yr. dep.)	1.05	.90	1.55	1.34
(10yr. dep.)	.53	.45	1.55	1.34

* Includes extra charges when used in excess of 176 hr./month

** Monthly rental cost, not depreciation costs.

Buildings and Facilities

	Purchase		Rental	
	24 Terminal Sys.	32 Terminal Sys.	24 Terminal Sys.	32 Terminal Sys.
Building and Facilities Total	*$23,000	*$25,000	*$23,000	*$25,000
Monthly Costs (Amortized 15 yrs. Straight-Line)	$ 128	$ 139	$ 128	$ 139
Instructional Hour Costs Based on System Use				
6 hr./day use	$ .040	$ .033	$ .040	$ .033
12 hr./day use	.020	.016	.020	.016
18 hrs./day use	$ .013	.011	.013	.011

* Estimated costs of building renovation/construction as reported by Post Engineers Office, Fort Monmouth, New Jersey

Table C-1 (Continued)

Installation and Costs*

	Purchase		Rental	
	24 Terminal Sys.	32 Terminal Sys.	24 Terminal Sys.	32 Terminal Sys.
Carrels, false flooring, etc.	$12,000	$15,000	$12,000	$15,000
Station Connectors	2,000	3,000	2,000	3,000
Installation Cabling	1,400	1,600	1,400	1,600
Miscellaneous **	1,200	1,200	1,200	1,200
TOTAL	$16,600	$20,800	$16,600	$20,800
Monthly Costs				
Depreciated 5 yrs. Straight-Line	$ 277	$ 347	$ 277	$ 347
Depreciated 10 yrs. Straight-Line	$ 138	173	138	173
Instructional Hour Costs Based on System Use				
6 hr/day use (5yr. dep.)	$ .088	$ .083	$ .088	$ .083
(10yr. dep.)	.044	.041	.044	.041
12hr/day use (5yr. dep.)	.044	.041	.044	.041
(10yr. dep.)	.022	.020	.022	.020
18hr/day use (5yr. dep.)	.029	.027	.029	.027
(10yr. dep.)	.014	.013	.014	.013

*All of the Installations cost data presented above are based on estimates since there are no firm plans of the IBM 1500 system physical layout available. These data are presented to demonstrate cost model methodology and are subject to change as final plans are completed. The variation in these data may be significant, and these costs should be recomputed based on firm plans when available.

**Covers unforeseen costs of installation such as freight or transportation charges and miscellaneous materials and supplies.

Table C-1 (Continued)

Estimated Capital Investments Costs Summary

	Options			
	Purchase		Rental	
	24 Terminal Sys.	32 Terminal Sys.	24 Terminal Sys.	32 Terminal Sys.
Hardware (Total)	$591,720	$678,380	---	---
Buildings and Facilities (Total)	23,000	25,000	$23,000	$25,000
Installation (Total)	16,600	20,800	16,600	20,800
Estimated Start-Up Costs	$631,320	$724,180	$39,600	$45,800

Monthly Costs CAI Capital Investments

Hardware				
Depreciated 5 years	$ 9,862	$ 11,306	$14,041**	$16,276**
Depreciated 10 years	4,931	5,653	14,560**	16,795**
Buildings and Facilities	$ 128	$ 139	$ 128	$ 139
Installation				
Depreciated 5 years	$ 277	$ 347	$ 277	$ 347
Depreciated 10 years	138	173	138	173
Total Monthly Costs				
(5 yr. depreciation)	$ 10,267	$ 11,792	$ 14,446	$ 16,762
(10 yr. depreciation)	5,197	5,965	14,307	16,588
(5 yr. depreciation)			$ 14,965	$ 17,281*
(10 yr. depreciation)			$ 14,826*	$ 17,107*

*Includes extra maintenance cost when metered units use in excess of 176 hrs/mo.

**Monthly rental costs for IBM 1500 System, not depreciation costs.

Table C-1 (Continued)

Instructional Hour Costs Based on Daily Use

	Purchase		Rental	
	24 Terminal Sys.	32 Terminal Sys.	24 Terminal Sys.	32 Terminal Sys.
6 hr/day use (5yr dep)	$3.29	$2.83	$4.62	$4.02
(10yr dep)	1.66	1.43	4.58	3.98
12 hr/day use(5yr dep)	1.64	1.42	2.39	2.07
(10yr dep)	.83	.72	2.37	2.05
18 hr/day use(5yr dep)	1.10	.94	1.60	1.38
(10yr dep)	.55	.48	1.58	1.37

Certain of these costs are incurred in support of each IBM 1500 Instructional System in operation regardless of how many hours per day the system is actively used for student instruction. These items of cost behave in the same way as costs of equipment depreciation: the greater the utilization of the equipment, the lower the cost per student-hour.

Other categories of continuing costs will vary directly with the amount of utilization made of the equipment. These continuing costs are basically constant per student-hour of instruction provided.

The four general categories of continuing costs are discussed in the following paragraphs and noted in Table C-2. How each element of cost behaves with different patterns of equipments utilization is described.

C. 2. 3. 1 System Maintenance

This cost category includes the cost of maintaining the hardware of the IBM 1500 Instructional System but excludes software or program maintenance. The cost data for this category are based on IBM standard system maintenance charges currently in effect and are subject to change as provided by the IBM/GSA Federal Supply Schedule. Maintenance costs are included in rental charges if this option is selected.

This cost category represents a fixed cost per instructional system and does not vary with the extent of usage made of the equipment. Hence greater machine utilization reduces the cost of maintenance per student hour.

C. 2. 3. 2 Operations

This cost categoryincludes system operations costs, electricity, cooling, humidity control, and other items pertinent to the day to day operation of the IBM 1500 Instructional System. Certain of these costs (e.g., cooling, humidity control) are incurred on a full-day basis for each IBM 1500 system largely independent of the amount of usage made of the equipment. Other components of these costs (e.g., electricity, personnel acting as computer operators and system proctors) vary directly with equipment utilization. These two types of cost are segregated in Table C-2.

Table C-2

CAI CONTINUING COSTS

	Purchase		Rental	
	24 Terminal System (Monthly)	32 Terminal System (Monthly)	24 Terminal System (Monthly)	32 Terminal System (Monthly)
Cost Independent of System Utilization				
System Maintenance	$1908	$2296	(Included in Rental Chg.)	
Operations	200	250	$ 200	$ 250
Overhead & Supplies	100	150	100	150
Total	$2208	$2696	$ 300	$ 400
Cost per 6 hour shift System Utilization				
Operations	$1240	$1320	$1240	$1320
Software Adaptation & Maintenance	133	200	133	200
Overhead & Supplies	300	400	300	400
Total	$1673	$1920	$1673	$1920
Instructional Hour Costs Base on System Use				
6 Hr./day use	$ 1.29	$ 1.15	$ .66	$ .58
12 Hr./day use	.92	.81	.61	.53
18 Hr./day use	.81	.70	.59	.51

The above cost data are based on estimates and presented to complete the cost model methodology. This cost information should be recomputed based on firm plans when available.

C.2.3.3 CAI Program Adaptation and Maintenance

This category includes the personnel, supplies, and materials required to adapt CAI programs to local requirements and the effort necessary to modify and update the course material as required. The personnel required and a brief description of their duties are provided in Section 4, Applicability, of this report. The size of staff required for this function depends only on the desired level of continuing instructional program revision and improvement; it is independent of the number of student stations used in the CAI system, since changes to the machine-readable programs may be performed under computer control once they have been written by the instructional programmers. As a result, the charge appearing in Table C-2 is a prorating of central program adaptation and maintenance costs to one of the several IBM 1500 Instructional Systems needed to handle the total current in-training load for the 26L20 MOS course.

C.2.3.4 Overhead and Supplies

This category includes all those prorated costs of a general housekeeping nature required to support the effort involved in the three preceding categories. As in the case of operations costs, these are divided into those which do and do not vary with daily usage of the IBM 1500 Instructional System.

C.2.3.5 Continuing Costs Summary

A summary of CAI continuing costs for the IBM 1500 Instructional System is provided in Table C-2.

When the cost of a CAI system installed in an activity other than an ongoing training activity is computed, student pay costs and various logistic support costs prorated for the time spent taking instruction could be included in this cost category. These costs at USASCS are included in the conventional instruction costs but are omitted here.

If a rental option for the IBM 1500 Instructional System is selected, it may be appropriate to include the monthly rental charges as continuing costs. However, the rental option costs are treated as capital investment costs in this analysis for reasons of consistency and comparability.

C. 2. 4 CAI Program Development Costs

In analysis of costs of CAI program development (software), four categories of costs tend to be logically associated in a model of CAI Program Development Costs:

1. Course material preparation
2. Course implementation and debugging
3. Training aids - supplies and materials
4. Overhead

The first two categories, involving functions or tasks and their costs, consist of the salary costs of the manpower required to accomplish the work.

Course material preparation for a CAI program requires professionals with various academic skills and backgrounds corresponding primarily to the subject of the course materials under preparation. Generally, subject specialists, educational specialists, and course writers are required.

Review of available salary information discloses a wide salary range for the preceding personnel based on education and experience (Table C-3).

Table C-3

EDUCATION AND SALARY FOR PROFESSIONALS

Education	Average Monthly Salary Range	
	0-4 years exper.	15 years exper.
Non degree	$ 575	$ 830
BS	735	1000
MS	875	1250
PhD	1165	1450

Course implementation and debugging also involves a group of closely related tasks requiring the services of a homogeneous skilled group of people. This group consists of programmers, coders, analysts, and other data processing personnel needed to take the output from the first group and interface it with the CAI system so that the CAI program becomes a useful computer-assisted instructional course capable of meeting course objectives. The costs of this category will also vary from location to location as well as with educational background and experience. Estimated salary ranges for these skills are given in Table C-4.

Table C-4

EDUCATION AND SALARY FOR DATA PROCESSING PERSONNEL

Education	Average Monthly Salary Range	
	0-4 years exper.	15 years. exper.
Non degree	$ 640	$ 850
BS	740	1100
MS	950	1400
PhD	1075	1700

Also included in the course implementation and debugging cost category is the cost of computer time required to support course development. One hundred hours of computer time were used during this study. Included in this cumulative time were such items as CAI demonstrations, tests, and the instructional time for the test students. Due to these complicating factors, there is no accurate accounting of the amount of computer time used specifically for the CAI course development effort. It must be pointed out that this represents initial effort under development conditions and may have very little relation to the computer time required in a production line implementation of CAI programs.

In addition, USASCS provided trial students and other personnel support for course validation and other tasks throughout this study. No cost data is provided for this effort, but such costs should be included in this cost category.

Training aids (supplies and materials) include graphic arts, film, photography, reproduction, tapes, paper, forms, printing, and all other materials required for the development of a CAI course. These items can generally be identified as direct costs for a specific course of instruction and will vary with the needs of the course. For this reason, this category is separated from the overhead cost category. There are little or no historical cost data for this category. The cumulative cost for the above listed items for converting the conventional eleven hours and fifteen minutes of USASCS course 26L20 to CAI course material was $6,890. It must be emphasized that these costs represent costs under developmental conditions and do not necessarily represent production line costs for CAI course development.

The prorated overhead category is included to account for all those items of cost required to support the CAI program development which cannot be readily identified with a specific course of instruction and to complete the model of CAI program development costs. The items in this category

should include all those costs that cannot logically be included in the preceding categories.

The cost of CAI program development is a significant consideration and, depending on the amortization and distribution schedules selected, makes a difference in cost of a few cents or dollars per instructional hour. It is axiomatic that the accounting treatment of these costs will have a major impact on the cost-competitiveness of the CAI system.

There is no precedent to provide a basis for selecting an amortization and distribution schedule. Logically, these schedules would vary widely, depending on the utility of the CAI program developed. For example, the first six weeks of course 26L20, Microwave Radio Equipment Repair, is essentially a course in basic electronics. With relatively minor local adapation this course could be used by all military services. With continuous updating as provided in the CAI System cost model, the useful life of this course could be extended almost indefinitely into the foreseeable future. Thus, there are many logical alternatives for amortizing and distributing software development costs for this segment of course 26L20. The other extreme would be amortizing and distributing the development cost of a highly specialized course of limited utility or application. Cost would at first seem prohibitive; however, consideration should be given to the ease of updating, storing and instant availability of the course with little or no start-up costs. When a skilled instructor is reassigned, the cost of training a replacement is involved or the instructional capability may be lost. A CAI course can be stored and, if updated periodically, retains a ready instructional capability. Due to the wide range of possibilities involved in any CAI program development cost computation and the very restrictive and limited data available in this feasibility study, cost computations have been omitted to preclude presenting misleading cost data. In lieu thereof, the estimated man-hours required to develop CAI course material from 11 hours and 15 minutes of conventional course 26L20 is presented in Table C-5.

Table C-5

REQUIRED MAN-HOURS

Professional Skill	Man-Hours
Project Manager	640
Subject Specialists	480
Education Specialists	640
Course Authors	1280
Programmers	1120
Coders	480
Keypunch	480
Secretarial	160
TOTAL	5280

It is estimated that 25% or 1320 hours of this total was spent in travel between the site of course preparation and Annapolis and Fort Monmouth. Deducting 25% of the preceding total man-hours leaves a total of 3960 productive man-hours.

In retrospect, much of the effort expended would be redirected if this effort were undertaken again. Due cognizance of this should be taken if cost estimates are computed based on the preceding man-hour data.

Two categories of CAI program costs (software) have been discribed: CAI program adaptation and maintenance, and CAI program development costs. At what point do CAI program development costs become CAI continuing costs? One approach is to charge all costs of CAI program development to the second category until the course objective as measured by student criterion test scores is achieved. At this point, program development has achieved its objective and can be defined as an operational course of instruction. Cost of subsequent change or adaptation would be a proper charge to the CAI adaptation and maintenance cost category.

C.2.5 Summary of CAI System Costs

After the CAI Instructional Hour cost for the various classifications and categories of cost described in the CAI cost model has been computed, it is a simple matter to multiply the Instructional Hour rate by the number of hours the student required to complete the course to arrive at estimated course costs. As provided for in this cost model, to calculate the cost of producing course graduates the prorated cost of additional training time incurred primarily as a result of attrition and waiting must be added to course cost to arrive at the student graduate costs. These latter costs provide a useful indication of the overall inefficiency of the training process. Adequate control of these costs is essential.

Table C-6 gives a summary of IBM 1500 CAI system student instructional hour costs.

Table C-6

SUMMARY OF STUDENT INSTRUCTIONAL HOUR COSTS

	Range Cost per Student Instructional Hour		
Capital Investments (CAI)			
Rental	$1.37	to	$4.62
Purchase	.48	to	3.29
Continuing Costs			
Rental	$ .51	to	$ .66
Purchase	.70	to	1.29
Total CAI Costs			
Rental	$1.88	to	$5.23
Purchase	1.18	to	4.58

NOTE:
1. Data are based on 24/32 terminal IBM 1500 5/10 year depreciation.
2. CAI program development costs (software) are excluded.

The following word equations demonstrate the arithmetic of computing course graduate cost.

CAI System Instructional Hour Rate x Student Instructional Hour = CAI System Course Costs

CAI Program Development Instructional Hour Rate x Student Instructional Hours = CAI Program Development Course Costs

CAI System Course Costs + CAI Program Development Course Cost = Course Costs

Course costs + Additional Training Time Costs = Course Graduate Costs
(Attrition)
(Waiting)

To compute the additional training time costs as a result of attrition and waiting time, student time data must be accumulated. This cost provides a method of identifying costs of inefficiencies of the instructional process and is a useful tool for analyzing performance of the instructional process.

Table C-7 below presents in tabular form a summary of CAI system costs.

Table C-7

SUMMARY OF CAI SYSTEM COSTS

		Number of Terminal Systems			
		Purchase		Rental	
		24 Term. System	32 Term. System	24 Term. System	32 Term. System
Total Cost per Instructional Hour					
Usage	**Depreciation**				
6 hr/day	5 yr.	$ 4.58	$ 3.98	$ 5.28	$ 4.60
6 hr/day	10 yr.	2.95	2.58	5.24	4.56
12 hr/day	5 yr.	2.56	2.23	3.00	2.60
12 hr/day	10 yr.	1.75	1.53	2.98	2.58
18 hr/day	5 yr.	1.91	1.64	2.19	1.89
18 hr/day	10 yr.	1.36	1.18	2.17	1.88
Total Cost per Course 26L20 Graduate (840 Instructional hours)					
Usage	**Depreciation**				
6 hr/day	5 yr.	$3847	$3343	$4435	$3864
6 hr/day	10 yr.	2478	2167	4402	3830
12 hr/day	5 yr.	2150	1873	2520	2184
12 hr/day	10 yr.	1470	1285	2503	2167
18 hr/day	5 yr.	1604	1378	1840	1588
18 hr/day	10 yr.	1142	991	1823	1579

Note: The preceding summary of CAI System costs do not include CAI program development costs.

C.3 COSTS OF CONVENTIONAL TRAINING (ALTERNATIVE 2)

C.3.1 General Procedure for Development of Conventional Training Costs

The general procedure for development of conventional training costs at USASCS was to identify all cost that could be directly related to a specific course of instruction and to distribute this cost proportionally to course classroom hours. The common distribution basis of 6 hours of instruction in a scheduled 8-hour day in a 260-schoolday year was used consistently with all applicable computations in this analysis. The objective was to arrive at a representative cost of the student instructional hour.

Data were accumulated on 45 courses of instruction at USASCS.

C.3.2 Conventional Training Cost Model

Conventional training costs are divided into two general classifications consistent with the CAI system costs classifications: capital investments and continuing costs. The conventional training costs include only those costs of the training entity at USASCS, Fort Monmouth, New Jersey, but exclude any Armywide distribution of overhead or support cost. A thorough system analysis of these costs would require consideration of all costs involved. Also, this report involves implied servicewide cost. Due to limited availability of cost data, however, this analysis has been restricted to the USASCS training environment at Fort Monmouth.

C.3.3 Conventional Training Capital Investment Costs

C.3.3.1 Facilities and Installations

The facilities and installations at USASCS used for training activities, faculty, and student body can be grouped into three general types of buildings: permanent, semi-permanent, and temporary. As the Fort Monmouth Post Engineers Office reported, permanent buildings are amortized straight-line over 25 years. Semi-permanent and temporary buildings are amortized over 15 years. These buildings are amortized at cost in accordance with generally accepted accounting conventions. The Fort Monmouth Post Engineers Office reports the total cost of USASCS

buildings as $8, 388, 598. This is conservative, since replacement costs are estimated at approximately $36, 000, 000. World War II temporary buildings are not included in this cost, since they have exceeded their amortization life, but the renovation and upkeep costs are included in the operations and maintenance costs. These building costs were amortized in accordance with the recommended amortization period and distributed proportionally to student classroom hours.

C. 3. 3. 2 Capital Equipment

This cost category should include all costs of capital equipment used by USASCS (e.g., radar, radios, test equipment, and other expensive equipment requiring large outlays of capital). Most of this equipment is included in the operations and maintenance cost and could not be separated from these data. One item listed in this category, the AN/MSC-46 satellite communications (Radome Disk), was depreciated over 15 years at a cost of $2, 000, 000 and distributed to student instructional hours.

The conventional training capital investment cost per student instructional hour is computed as $. 042. This is considered a very conservative estimate and not a significant cost factor (Table C-8).

Table C-8
CAPITAL INVESTMENT COSTS

Facilities and Installations	
Permanent Building Total	$7,622,334
Amortized 25 yrs. straight-line, monthly costs	25,408
Semi-Permanent Buildings Total	331,064
Amortized 15 yrs. straight-line, monthly costs	1,839
Temporary Buildings Total	435,200
Amortized 15 yrs. straight-line, monthly costs	2,418
Capital Equipment	
Radome Dish total	$2,000,000
Amortized 15 yrs. straight-line, monthly costs	11,111
Total Monthly Amortized Costs	$ 40,776

Instructional Hour Cost

$$\frac{\$40{,}776 \text{ (Total Monthly Amortized Costs)}}{7419 \text{ (Avg. student in training Jan-July 1967)} \times 21.7 \text{ (school days per month)} \times 6 \text{ hrs/day}} = \$.042 \text{ student instructional hour costs}$$

	Course 26L20	Mean 45 Courses
Facilities and Installations Course Costs	$35	$23

C. 3. 3. 3 Conventional Training Continuing Costs

This classification includes two broad categories of costs: Operations and Maintenance, Army Appropriation Costs (O & M, A), and Military Personnel Costs (Mil Pers).

C. 3. 3. 4 Operations and Maintenance, Army Appropriations

USASCS completed a detailed analysis of the O & M, A cost of various courses at USASCS in early summer, 1967. The data on 45 courses are used in this analysis. The O & M, A costs are further grouped into mission costs and base operations costs.

Mission costs include primarily all those costs that can be related directly to a specific course. These costs were then distributed to instructional hours of that course. Those costs not directly related to a specific course were distributed proportionally to all courses and instructional hours.

C. 3. 3. 5 Base Operations Costs

This category, formerly known as operations and maintenance of facilities (OMF), includes those costs of operating Fort Monmouth in support of tenant activities. The identified costs were distributed proportionally over all courses and instructional hours.

A summary of O & M, A cost of producing student graduates per instructional hour is given in Table C-9.

Table C-9

STUDENT INSTRUCTIONAL HOUR COSTS

Range	\$1. 14 to \$6. 69
Course 26L20	\$1. 52
Mean of 45 courses	\$2. 18

The above costs, the instructional hour costs of producing course graduates, include the costs of additional training time distributed to course graduates. Data on additional training costs due to attrition and waiting time was not available, and these costs could not be separated.

Table C-10 below is a summary of O&M, A costs applicable to courses of instruction at USASCS.

Table C-10
OPERATIONS AND MAINTENANCE, ARMY APPROPRIATION (O & M, A)

Mission Costs

Items	Course 26L20	Mean 45 Courses
Civilian Instructor	$ 218	$ 325
Training Aids	6	31
Supplies and Materials	52	110
Overhead	300	282
Total Mission Costs	$ 576	$ 748

Base Operations Costs

Item	Course 26L20	Mean 45 Courses
Renovation	$ 10	$ 7
Repair, Utilities, Janitorial Services	307	203
Headquarters Services	193	128
Recreation and Welfare Services	11	7
Maintenance Services	53	35
Communications and Pictorial Services	7	5
Transportation Services	14	10
Unidentified Costs (Prorated)	106	70
	$ 701	$ 465
Total O & M, A Costs	$ 1,277	$ 1,213
Instructional Hours Costs	$ 1.52	$ 2.18

The length of course 26L20 is 28 weeks or 840 hours of instruction, based on six hours per instructional day. The average for 45 courses at USASCS is 18.5 weeks or 556 hours of instruction.

C.3.3.6 Military Personnel Costs (Mil Pers)

Military Personnel costs are based on planning figures rather than a precise analysis of each pay account involved. The military pay factors used in computing military personnel costs were the group pay rates, as set forth in AR 37-29 as amended by Army message 142005Z of July 1967 (Subject: accounting and reporting for the cost of military personnel services). The data on personnel numbers and pay grades was obtained from the USASCS Personnel and Registrar Offices.

C.3.3.7 Categories of Mil Pers Costs

Three categories of Mil Pers costs are computed: military instructor, student pay, and military staff and other assigned personnel. Military instructor is a separate cost category, since this category along with civilian instructor costs would most likely be redistributed with the use of a CAI system. Student pay, the major cost category in this classification of costs, is identified for analytical purposes. Military Staff and other assigned personnel represent those military personnel at USASCS required to support the training activities.

The general procedure for computing these costs was to determine the mean monthly population by pay grade at Fort Monmouth for January through July 1967 and multiply by the applicable monthly pay grade rate. The monthly cost was then distributed to the monthly student instructional hours.

This procedure does not take into consideration variations in instructional time as a result of student attrition, student recirculation, and student waiting time. If has been estimated that Mil Pers costs of the student graduate may be increased by as much as 5% by these factors. However, there are no reliable data, on the variation in instructional time as a result of these factors, on which to compute adjustments. Although these adjustments may increase the conventional costs, they will not significantly affect the cost-comparisons and have been omitted in keeping with the conservative estimates of conventional training.

Table C-11 below presents in detail calculations supporting estimates of military personnel costs.

Table C-11

MILITARY PERSONNEL COSTS

Student Pay and Allowances
Average Student Population (January through July 1967)

Pay Grade	Number	Costs
E-2	5765	$ 1, 251, 005
E-3	1038	225, 246
E-4	220	98, 340
E-5	253	113, 091
E-6	120	53, 640
E-7	21	15, 372
E-8	2	1, 464
TOTAL	7419	1, 758, 158

Distribution

$$\frac{\$1,758,158 \text{ (Student pay and allowances)}}{7419 \times 21.7 \text{ days/month} \times 6 \text{ hrs./day}} = \$1.82$$

Cost per student hour: $1.82

	Course 26L20	Mean of 45 Courses
Student Pay and Allowances Cost per Course	$1529*	$1012*

* Rounded to even dollar cost

Military Instructors
Average - (January through July 1967)

Pay Grade	Number	Costs
W1-W4	10	$ 7, 430
E-9	7	5, 124
E-8	43	31, 476
E-7	538	393, 816
E-6	1087	485, 889
E-5	5	2, 235
TOTAL	1814	925, 970

Distribution

$$\frac{\$925,970 \text{ (Military Instructors)}}{7419 \times 21.7 \text{ (school days/month} \times 6 \text{ hrs./day)}} = \$.96$$

Cost per student hour: $.96

	Course 26L20	Mean of 45 Courses
Military Instructor Cost per Course	$806*	$534*

*Rounded to even dollar costs

Table C-11 (Continued)

Military Staff and Other Assigned Military Personnel
Average - (January through July 1967)

Pay Grade	Number	Costs
09-10	1	$ 2,064
06	11	14,333
05	36	46,908
04	42	54,726
03	55	40,865
02	27	20,061
W1-W4	8	5,944
E-9	8	5,856
E-8	34	24,888
E-7	52	38,064
E-6	83	37,101
E-5	229	102,363
E-4	176	78,672
E1-E3	176	38,192
TOTAL	936	$ 510,037

Distribution

$$\frac{\text{\$510,037 (Military staff and other assigned personnel)}}{\text{7419 x 21.7 (school day/month x 6 (hrs. /day)}} = \$.53$$

Cost per student hour: $.53

	Course 26L20	Mean of 45 Courses
Military Staff and Other Assigned Personnel Cost per Course	$445*	$295*

*Rounded to even dollar cost

A summary of average military personnel costs per student instructional hour is as follows:

Student Pay	$1.82
Military Instructor Pay	.96
Military Staff and Other	.53
TOTAL	$3.31

NOTE: Military Personnel costs were developed using pay-grade group rates in accordance with AR37-29 as amended by Army message R142005Z of July 1967, subject: Accounting and Reporting for the cost of Military Personnel Services.
Data on numbers of students were obtained from the USASCS Registrar's office and data on number of military staff and other assigned personnel were provided by the USASCS personnel office.

C.3.4 Conventional Instruction Course Development Cost

This classification of conventional instruction cost is defined for comparative purposes and for completion of the cost analysis methodology, since the costs are comparable to CAI program development costs. No data are collected on this cost classification. Some of these costs are included in the cost data for conventional training data (O & M, A and military personnel costs). Cost items such as curriculum development and training material preparation are examples of the effort at USASCS which would be included in this category but cannot be separated from the available cost data.

Also, development of training materials or literature (e.g., training films and technical manuals) used by USASCS but not developed by USASCS involves costs. These items, not included in USASCS cost data, are financed from other sources but should be included in this cost category for comparative purposes.

C.3.4.1 Course Material Preparation

This cost category involves the concerted effort of professional personnel (e.g., course writers, subject specialists and education specialists) as required to prepare the outline, objectives, and informational material for development of a new conventional course of instruction. Costs include salaries of the employees involved in this effort.

C.3.4.2 Editing and Reviewing

This cost category also involves the joint effort of persons on a professional level somewhat different from those required for course material preparation.

It may be appropriate to combine this category with the preceding category, but for comparison purposes it is identified separately

since a definite parallel with the cost categories of CAI program development exists. The costs of this category are the salaries of the employees.

C. 3. 4. 3 Illustrations - Supplies and Materials

This category includes the costs of the graphic arts, training aids, printing, reproduction, paper, typing, and similar items required in developing a new course of instruction. These costs apparently vary widely, depending primarily upon the course being developed. A comparable cost category is included in the CAI program development model, and similar variations in cost are to be expected.

C. 3. 4. 4 Prorated Overhead

To complete the cost model and include all costs, the prorated overhead cost required to support the course development effort must be included. This includes housekeeping and logistic support necessities, such as a prorated share of those items included in the base operations (O & M, A) costs at Fort Monmouth.

The amortization and distribution of conventional course development costs will have an impact on conventional training similar to their effect on CAI program development costs.

C. 3. 4. 5 Summary of Conventional Training Costs

The summary of conventional training cost of producing course graduates per student instructional hour is given in Table C-12.

Table C-12

STUDENT INSTRUCTIONAL HOUR COSTS

Cost Type	Course 26L20	Mean of 45 Courses
Capital Investments		
Facilities and Installations	$ .03	$ .03
Capital Equipment	.01	.01
Continuing Costs		
O & M, A	1.52	2.18
Mil Pers	3.31	3.31
Total Instructional Hour Costs	$ 4.87	$ 5.53

Range of Total Instructional Hour Costs for 45 Courses

$ 4.76 to $ 10.03

C.4 COMBINING CONVENTIONAL TRAINING AND CAI SYSTEM (ALTERNATIVE 3)

Installation of an IBM 1500 Instructional System at USASCS introduces a new training system into an on-going conventional training environment. The cost of producing course graduates then becomes a combination of the cost of the CAI system and the modified costs of the on-going conventional training.

The cost category in the conventional training environment which CAI may most reasonably be expected to reduce is the category of instruction (both military and civilian) costs. This reduction would be brought about not by a reduction in manpower level, but by a shift in the roles played by the same men. Specifically, instructors used in the classroom and to support classroom activities would, with CAI, shift their duties to proctoring the CAI system and operating the computers. The cost figures presented in this analysis show military and instructor costs reduced by a conservative estimate of 50% and the costs of CAI system proctoring and computer operation included in the category "CAI Costs". The instructor remaining with the CAI system would be used not in the conventional manner, but for individual student counseling in support of student use of the CAI system.

The shifting of what were instructor costs for the conventional training environment into proctoring and computer operating CAI costs does not itself lead to the economies in the conventional training environment which justify the CAI system. These economies come primarily from one of the major comparative strengths of the CAI method of instruction: its demonstrated ability to increase the efficiency of the instructional process through reduction of total training time. When total training time required per course graduate is reduced, all cost categories (whether they are present in the original conventional training environment or arise directly from use of the CAI system itself) are reduced proportionately.

Table C-13 illustrates these points. Comparison of the leftmost two columns shows, under the condition of no change in total instructional time, how CAI may be expected to reduce conventional military and civilian instructor costs, and also shows the more-than-offsetting additional cost of the CAI system. The third column, however, shows the CAI instructional costs fall with the anticipated decrease in instructional time. Comparison of the rightmost column with the conventional

Table C-13

COMPARATIVE COST OF PRODUCING A COURSE GRADUATE

Fort Monmouth Course 26L20 Costs

	Conv.	CAI - Conv. Costs Combined Instructional Time	
		No Reduction	20% Reduction
Mil Instructor (Mil Pers)	$ 806	$ 403	$ 322
Civ. Instructor (O & M, A)	218	109	87
Mission (O & M, A)	358	358	286
Base Ops (O&M, A)	701	701	561
Mil Staff (Mil Pers)	445	445	356
Student Pay (Mil Pers)	$1,529	1,529	1,223
Facilities and Installation	35	35	28
Total Conv Costs	$4,092	$3,580	$2,863
CAI Costs	---	1,142	914
Total Grad Costs	$4,092	$4,722	$3,777

NOTE: The CAI cost data is based on a 24 terminal IBM 1500 Instructional System used for 18 instructional hours a day 5 days a week and depreciated over 10 years straight-line.

costs shows that, with a 20% reduction in instructional time, total costs under CAI are lower (by $315) than the original conventional costs. This illustrates the general principle that savings in instructional time obtainable with CAI will more than offset the additional costs of the CAI equipment and lead to a net reduction in total training costs per course graduate.

If the instructional effectiveness of course material is considered in addition to economies, the best teaching strategy might well be a combination of conventional instruction used for some lessons and

CAI used for others. Within those lessons in which CAI is used, however, instructional time will still be reduced and the same relative economic advantage of CAI obtained. With a mixed instructional strategy such as this, total costs per course graduate may be estimated by applying conventional instruction hourly rates to those hours taught conventionally, and applying the corresponding CAI rates to those hours taught by CAI, provided that student scheduling is performed in such a manner as to allow realization of time savings through CAI.

It should be noted that the cost comparisons provided in Table C-13 are based upon the selection of the CAI Instructional System configuration and usage referred to in the note to that table. Tables C-14 through C-17 provide in detail equivalent comparisons based upon other possible selections of system configuration and usage.

Figure C-1 illustrates graphically how the cost comparisons are related to savings in instructional time for selected alternatives in these tables.

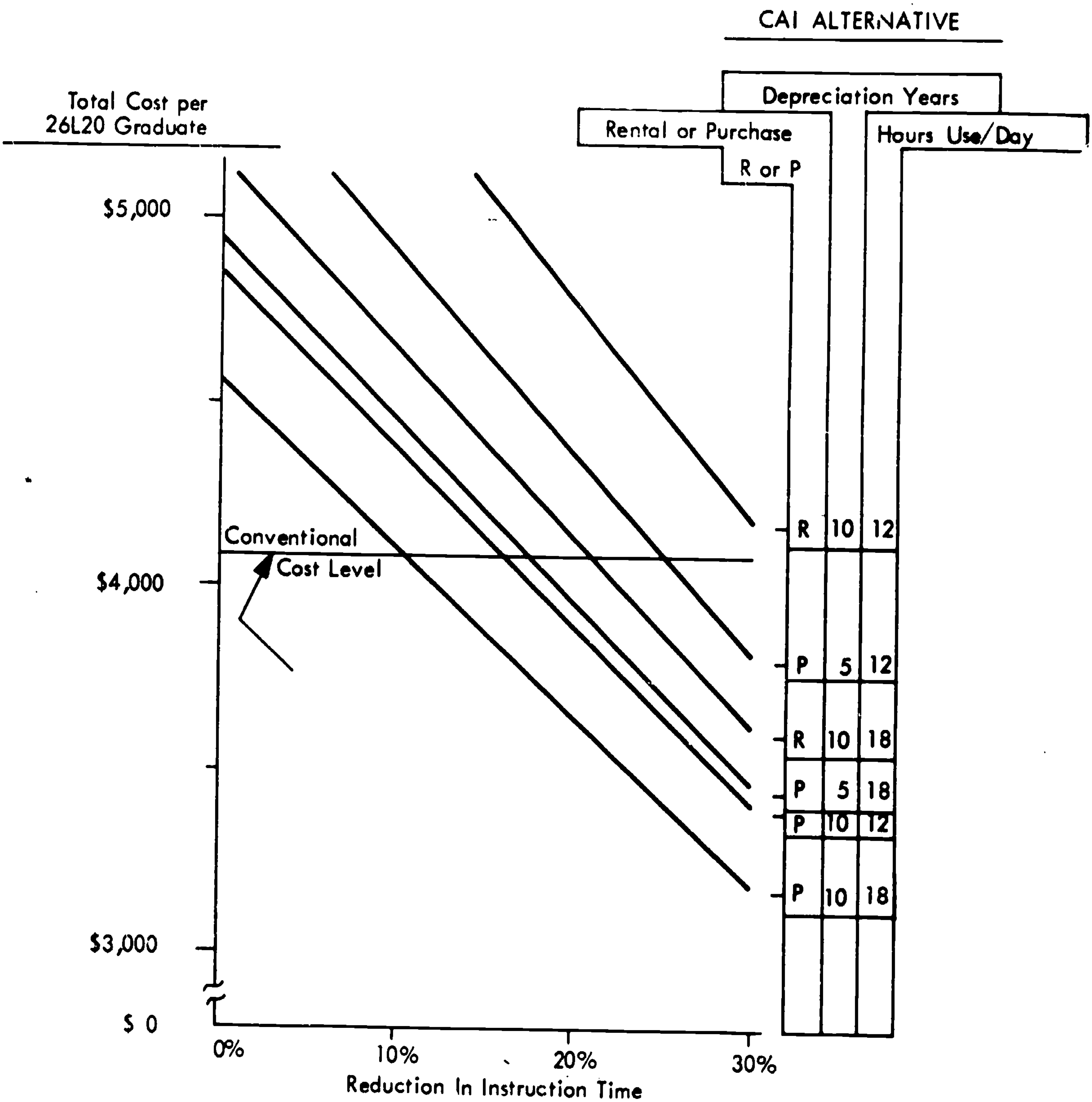


Figure C-1. Comparison of Conventional and CAI Costs for 32-Station IBM 1500 Instructional System*

*Costs for 24-Station IBM 1500 are about $150-300 per Graduate higher than equivalent costs for 32-Station IBM 1500.

Table C-14
COMPARATIVE COURSE GRADUATE COSTS
CONVENTIONAL VS CAI COURSE 26L20

Purchase Option

	IBM 1500 System Purchase Option - 5 Year Depreciation (Hardware)*				
COST CATEGORY Conventional Instruction Costs	Conventional Instruction**	CAI None***	CAI 10%***	CAI 20%***	CAI 30%***
Military Instructors	$ 806	$ 403	$ 363	$ 322	$ 282
Civilian Instructors	218	109	98	87	76
Mission	358	358	322	286	251
Base Operations	701	701	631	561	491
Military Staff & Other Assigned Personnel	445	445	401	356	312
Student Pay	1,529	1,529	1,376	1,223	1,070
Facilities & Installations	35	35	32	28	25
Total Conventional Costs	$4,092	$3,580	$3,223	$2,863	$2,507
CAI IBM 1500 24 Stations					
6 hrs. use/school day		$3,847	$3,462	$3,078	$2,693
12 hrs. use/school day		2,150	1,935	1,720	1,505
18 hrs. use/school day		1,604	1,444	1,284	1,123
Tot. Course Costs/Student					
6 hrs. CAI use/school day		$7,427	$6,685	$5,941	$5,200
12 hrs. CAI use/school day		5,730	5,158	4,583	4,012
18 hrs. CAI use/school day		5,184	4,667	4,147	3,630
CAI IBM 1500 32 Stations					
6 hrs. use/school day		$3,343	$3,009	$2,675	$2,340
12 hrs. use/school day		1,873	1,686	1,499	1,311
18 hrs. use/school day		1,378	1,240	1,102	964
Tot. Course Costs/Student					
6 hrs. CAI use/school day		$6,923	$6,232	$5,538	$4,847
12 hrs. CAI use/school day		5,453	4,909	4,362	3,818
18 hrs. CAI use/school day		4,958	4,463	3,965	3,471

* Capital Investments in the IBM 1500 System Hardware are Depreciated Over 5 years

** The initial 50% reduction in conventional instructor cost is included in the CAI costs under the CAI continuing cost classification as proctors and computer operators.

*** Reduction Instruction Time

Table C-15
COMPARATIVE COURSE GRADUATE COSTS
CONVENTIONAL VS CAI COURSE 26L20

Rental Option

COST CATEGORY Conventional Instruction Costs	IBM 1500 System Rental Option - 5 Year Depreciation (Installation Costs)*				
	Conventional Instruction**	CAI None***	CAI 10%***	CAI 20%***	CAI 30%***
Military Instructors	$ 806	$ 403	$ 363	$ 322	$ 282
Civilian Instructors	218	109	98	87	76
Mission	358	358	322	286	251
Base Operations	701	701	631	561	491
Military Staff & Other Assigned Personnel	445	445	401	356	312
Student Pay	1,529	1,529	1,376	1,223	1,070
Facilities & Installations	35	35	32	28	25
Total Conventional Costs	$4,092	$3,580	$3,223	$2,863	$2,507
CAI IBM 1500 24 Stations					
6 hrs. use/school day		$4,435	$3,992	$3,548	$3,105
12 hrs. use/school day		2,520	2,268	2,016	1,764
18 hrs. use/school day		1,840	1,656	1,472	1,288
Tot. Course Costs/Student					
6 hrs. CAI use/school day		$8,015	$7,215	$6,411	$5,612
12 hrs. CAI use/school day		6,100	5,491	4,879	4,271
18 hrs. CAI use/school day		5,420	4,879	4,335	3,795
CAI IBM 1500 32 Stations					
6 hrs. use/school day		$3,864	$3,478	$3,091	$2,705
12 hrs. use/school day		2,184	1,966	1,747	1,529
18 hrs. use/school day		1,588	1,429	1,270	1,111
Tot. Course Costs/Student					
6 hrs. CAI use/school day		$7,444	$6,701	$5,954	$5,212
12 hrs. CAI use/school day		5,764	5,189	4,610	4,036
18 hrs. CAI use/school day		5,168	4,652	4,133	3,618

* IBM 1500 System Installation Costs are depreciated over 5 years.

** The initial 50% reduction in conventional instructor cost is included in the CAI costs under the CAI continuing cost classification as proctors and computer operators.

*** Reduction Instruction Time.

Table C-16
COMPARATIVE COURSE GRADUATE COSTS
CONVENTIONAL VS CAI COURSE 26L20

Purchase Option

COST CATEGORY Conventional Instruction Costs	IBM 1500 System Purchase Option - 10 Year Depreciation (Hardware)*				
	Conventional Instruction**	CAI None***	CAI 10%***	CAI 20%***	CAI 30%***
Military Instructors	$ 806	$ 403	$ 363	$ 322	$ 282
Civilian Instructors	218	109	98	87	76
Mission	358	358	322	286	251
Base Operations	701	701	631	561	491
Military Staff & Other Assigned Personnel	445	445	401	356	312
Student Pay	1,529	1,529	1,376	1,223	1,070
Facilities & Installations	35	35	32	28	25
Total Conventional Costs	$4,092	$3,580	$3,223	$2,863	$2,507
CAI IBM 1500 24 Stations					
6 hrs. use/school day		$2,478	$2,230	$1,982	$1,735
12 hrs. use/school day		1,470	1,323	1,176	1,029
18 hrs. use/school day		1,142	1,028	914	800
Tot. Costs/Graduate					
6 hrs. CAI use/school day		$6,058	$5,453	$4,84[illegible]	$4,242
12 hrs. CAI use/school day		5,050	4,546	4,039	3,536
18 hrs. CAI use/school day		4,722	4,251	3,777	3,307
CAI IBM 1500 32 Stations					
6 hrs. use/school day		$2,167	$1,950	$1,734	$1,517
12 hrs. use/school day		1,285	1,157	1,028	900
18 hrs. use/school day		901	892	793	694
Tot. Costs/Graduate					
6 hrs. CAI use/school day		$5,747	$5,173	$4,597	$4,024
12 hrs. CAI use/school day		4,865	4,380	3,891	3,407
18 hrs. CAI use/school day		4,571	4,115	3,656	3,201

* Capital investments in the IBM 1500 System Hardware are depreciated over 10 years.

** The initial 50% reduction in conventional instructor cost is included in the CAI costs under the CAI continuing cost classification as proctors and computer operators.

*** Reduction Instruction Time.

Table C-17
COMPARATIVE COURSE GRADUATE COSTS
CONVENTIONAL VS CAI COURSE 26L20

Rental Option

COST CATEGORY Conventional Instruction Costs	Conventional Instruction**	IBM 1500 Rental Option - 10 Year Depreciation (Installation Costs)* CAI None***	CAI 10%***	CAI 20%***	CAI 30%***
Military Instructors	$ 806	$ 403	$ 363	$ 322	$ 282
Civilian Instructors	218	109	98	87	76
Mission	358	358	322	286	251
Base Operations	701	701	631	561	491
Military Staff & Other Assigned Personnel	445	445	401	356	312
Student Pay	1,529	1,529	1,376	1,223	1,070
Facilities & Installations	35	35	32	28	25
Total Conventional Costs	$4,092	$3,580	$3,223	$2,863	$2,507
CAI IBM 1500 24 Stations					
6 hrs. use/school day		$4,402	$3,962	$3,521	$3,081
12 hrs. use/school day		2,503	2,253	2,003	1,752
18 hrs. use/school day		1,823	1,641	1,458	1,276
Tot. Course Costs/Student					
6 hrs. CAI use/school day		$7,982	$7,185	$6,384	$5,588
12 hrs. CAI use/school day		6,083	5,476	4,866	4,259
18 hrs. CAI use/school day		5,403	4,864	4,321	3,783
CAI IBM 1500 32 Stations					
6 hrs. use/school day		$3,830	$3,447	$3,064	$2,681
12 hrs. use/school day		2,167	1,950	1,734	1,517
18 hrs. use/school day		1,579	1,421	1,263	1,105
Tot. Course Costs/Student					
6 hrs. CAI use/school day		$7,410	$6,670	$5,927	$5,188
12 hrs. CAI use/school day		5,747	5,173	4,597	4,024
18 hrs. CAI use/school day		5,159	4,644	4,126	3,612

* IBM 1500 System Installation Costs are depreciated over 10 years.

** The initial 50% reduction in conventional instructor cost is included in the CAI costs under the CAI continuing cost classification as proctors and computer operators.

*** Reduction Instruction Time.

BIBLIOGRAPHY

Adams, E.N. "Roles of the Electronic Computer in University Instruction," IBM Research Report RC1530, IBM Watson Research Center, Yorktown Heights, 1965, 14 pp.

Adams, E.N., "Computer Assisted Instruction," Computers and Automation, March 1966, pp. 12-13, 41.

Automated Education Letter, Educational Press Association of America, Vol. 2, No. 9, July-August 1967.

Bauldree, A., "A Study of Individual and Group Differences in Learning Under Two Different Modes of Computer-Assisted Instruction," unpublished doctoral dissertation, Florida State University, Tallahassee, 1967.

Betts, J.M., "A Study of the Use of a Programmed Instruction for Presenting the Subject of Determinants to Students of Science and Engineering," unpublished Master's thesis, School of Engineering Science, Florida State University, 1966.

Betts, J.M., "Analysis of Data Generated by Computer-Assisted Instruction Systems," Seminar in Educational Research, Florida State University, March 1967.

Betts, J.M., "Computer-Assisted Instruction of Elementary College Physics," read at the Annual Meeting of the Florida Association of Physics Teachers in Tampa, Florida, March 1967.

Bitzer, D.L. and Easley, J.A., "PLATO: A Computer-Controlled Teaching System," Symposium on Computer Augmentation of Human Reasoning, University of Illinois, M.A. Sass and W.D. Wilkinson, editors, Spartan Books, Inc.

Bitzer, D.L., Braunfeld, P.G., and Lichtenberger, W.W., "PLATO II: A Multiple-student, Computer-controlled Automatic Teaching Device," Programmed Learning and Computer-based Instruction, edited by J.E. Coulson, John Wiley and Sons, New York, 1962, pp. 205-216.

Bitzer, D.L., Lyman, E.R. and Easley, J.A., "The Uses of PLATO: A Computer-Controlled Teaching System," Audiovisual Instruction, January 1966.

Brian, D., "The THOR Language," cited in D.N. Hansen," Computer Assistance with the Educational Process."

Briggs, L.J., Gagné, R.M., and May, M.A., "A Procedure for Choosing Media for Instruction," Instructional Media: A Procedure for the Design of Multi-media Instruction, A Critical Review of Research, and Suggestions for Future Research, American Institutes for Research, Pittsburgh, 1967, pp. 28-29.

Cieri, V.P. and Blanchard, C.M., "Fiscal Year 1966 Course Attrition of Army Service Schools Under Supervision of US Continental Army Command," Evaluation Division, Office of Academic Operation, US Army Signal Center and School, Fort Monmouth, New Jersey, March 1967.

Cochran, W.G. and Cox, G.M., Experimental Design, New York, John Wiley and Sons, Inc., 1957.

Cogswell, J.F., Donahoe, C.P., Estavan, D.P., and Rosenquist, B.A., "The Design of a Man-Machine Counseling System," SP-2576/001/01, System Development Corporation, Santa Monica, California, September 1966. (AD-640653)

Coulson, J.E., editor, Programmed Learning and Computer-Based Instruction, Proceedings of the Conference on Application of Digital Computers to Automated Instruction, October 10-12, 1961, John Wiley and Sons, Inc., New York, 1962.

Coulson, J.E., "Programmed Decisions in Programmed Instruction," SP-933/001/00, Systems Development Corporation, Santa Monica, California, AD-288837, August 13, 1962.

Crowder, N., "Automatic Teaching: The State of the Art," in Automatic Teaching: the State of the Art, edited by E.H. Galanter, John Wiley and Sons, Inc., New York, 1959, cited in Betts (1966).

Dick, W., "The Development and Current Status of Computer-Based Instruction," American Educational Research Journal, Vol. 2, No. 1, January 1965, pp. 41-54.

Eisenhart, C., "The Assumptions Underlying the Analysis of Variance," Biometrika, 1947, Vol. 3, pp. 1-21.

Engel, G.L., "Computer Assisted Instruction: A Selected Bibliography and KWIC Index," U.S. Naval Weapons Laboratory, Dahlgren, Virginia, AD-645654, January 1967.

Engvold, K.L., and Hughes, J.L., "A Model for a Multifunctional Teaching System," Communications of the ACM, 10: No. 6, June 1967, pp. 339-342.

ENTELEK, CAI Research Abstracts, ENTELEK Incorporated, Newburyport, Massachusetts, 1965.

ENTELEK, "DOD CAI Projects," News About CAI, Vol. II: No. 12, December 1967, p. 2.

Farber, D.L., Griswold, R.E., and Polonsky, I.P., "SNOBOL -- A String Manipulation Language," Journal of the Association for Computing Machinery, Vol. 2, No. 1, January 1964, pp. 21-30.

Feingold, S., "A Flexible Language for Programming Computer/Human Interaction," System Development Corporation, Santa Monica, California, February 28, 1966.

Feldman, J., "Computers, Instructions, and Learning," Joint Semi-Annual Report UCI-IBM, Educational Applications Project, University of California at Irvine, February 1, 1967 through July 30, 1967.

Feurzeig, W., "Towards More Versatile Teaching Machines," Computers and Automation, March 1965, pp. 22-24.

Feurzeig, W., "Conversational Teaching Machine," Datamation, June 1964, pp. 38-42.

Filep, R.T., Aigner, B.W., and Murphy, D.B., "A Feasibility and Requirements Study for a Computer-Assisted Learning System in Navy Education and Training Programs," TM(L)-3215/002/00A, System Development Corporation, Santa Monica, California, March 31, 1967.

Gagné, R.M., The Conditions of Learning, Holt, Rinehart, and Winston, New York, 1965.

Gentile, J.R., "The First Generation of Computer-Assisted Instructional Systems: An Evaluative Review," CAI Laboratory, Pennsylvania State University, College of Education, November 1965, 42 pp.

Gentile, J.R., "First Generation of Computer-Assisted Instructional Systems: An Evaluative Review," AV Communications Review, Vol. 15, No. 1, Spring 1967, pp. 23-53.

Gerard, R.W., "Computers and Education," Proceedings of the Fall Joint Computer Conference, American Federation of Information Processing Societies, Vol. 27, Part 2, Washington, D.C., 1965, pp. 11-16.

Glaser, R., editor, Teaching Machines and Programmed Learning II: Data and Directions, Department of Audiovisual Instruction, National Education Association, Washington, D.C. 1965.

Goodman, L., "Computer-Based Instruction: Today and Tomorrow," Data Processing for Education, Vol. 2, 1965, pp. 2-5.

Gropper, G.L., "Does 'Programmed' Television Need Active Responding?" AV Communications Review, Vol. 15, No. 1, Spring 1967, pp. 5-22.

Grubb, R.E. and Selfridge, L.D., "Computer Tutoring in Statistics," Computers and Automation, Vol. 13, No. 3, March 1958.

Halpern, M., "Foundations of the Case for Natural-Language Programming," IEEE Spectrum, Vol. 4, No. 3, March 1967, pp. 140-149.

Hamblen, J.W., "Education and the Computer: Pluses and Minuses in the Educational Equation," AEDS Monitor, Vol. 6, No. 3, October 1967, pp. 14-17.

Hansen, D.N., "Applications of Computers to Research and Instruction," presented to the National Society of College Teachers of Education in Chicago, February 17, 1966, cited in Hansen (1966b).

Hansen, D.N., "Computer Assistance with the Educational Process," Review of Educational Research, Vol. 36, No. 5, Chap. 7, December 1966b.

Hansen, D.N., and Dick, W., Semi-Annual Progress Report, January 1, 1967 through June 30, 1967, No. 5, Computer-Assisted Instruction Center, Institute of Human Learning, Florida State University, July 1967, 247 pp.

Hansen, D.N., and Dick, W., "CAI Sequential Testing," Semi-Annual Progress Report No. 5, Computer-Assisted Instruction Center, Institute of Human Learning, Florida State University, July 1967, pp. 58-64.

Hansen, D.N., and Franceschi, D., "An Experimental Study to Determine the Effectiveness of Supplementing Instructional Television with Computer-Assisted Instruction," Semi-Annual Progress Report No. 5, Computer-Assisted Instruction Center, Institute of Human Learning, Florida State University, July 1967, pp. 82-92.

Hansen, D.N., Snyder, W., and Burkman, E., "Curriculum Evaluation via CAI for the Intermediate Science Curriculum Study," Semi-Annual Progress Report No. 5, Computer-Assisted Instruction Center, Institute of Human Learning, Florida State University, July 1967, pp. 46-58.

Hickey, A.E., and Newton, J.M., Computer-Assisted Instruction - A Survey of the Literature, Second Edition, ENTELEK, Inc., Newburyport, Massachusetts, 1967.

Hirsch, R.S., and Moncreiff, B., "A Simulated Chemistry Laboratory," presented at the Fifty-Sixth National Meeting of the American Institute of Chemical Engineers in San Francisco, California, May 1965.

Holtzman, W.H., Bunderson, C.V., and Dunham, J.L., The University of Texas Laboratory for Computer-Assisted Instruction, 1966-67, Computer-Assisted Instruction Laboratory, University of Texas, August 1967.

International Business Machines Corporation, "IBM 1401, 1440, or 1460 Operating System, Computer Assisted Instruction," IBM Systems Referance Library, c24-3252-1, Endicott, New York, March 1956, 30 pp.

International Business Machines Corporation, "IBM 1500 Instructional System, Introduction to Computer-Assisted Instruction and System Summary," Instructional System Marketing Department, Systems Development Division, San Jose, California, June 16, 1967, 46 pp.

International Business Machines Corporation, "IBM 1500 Instructional System, CAI, Student's Guide," Instructional Systems Marketing Development, Systems Development Division, San Jose, California July 1, 1967, 34 pp.

International Business Machines Corporation, "COURSEWRITER Text Processing Functions," Instructional Systems Marketing Department, Systems Development Division, San Jose, California, July 13, 1967, 29 pp.

International Business Machines Corporation, "IBM 1500 Instructional System, CAI, Programming System User's Guide," Instructional Systems Marketing Department, Systems Development Division, San Jose, California, July 31, 1967, 203 pp.

International Business Machines Corporation, "IBM 1500 Instructional System Station Commands, User's Guide," Instructional Systems Marketing Department, Systems Development Division, San Jose, California, August 22, 1967, 105 pp.

International Business Machines Corporation, "1500 Operating System, Computer-Assisted Instruction, COURSEWRITER II Systems Summary," Product Publications Department, San Jose, California CAI-4036-1, 1967, 45 pp.

Iverson, K., A Programming Language, John Wiley and Sons, Inc., New York, 1962, 286 pp.

Jettson, B., and Walmark, J. T., "An Experiment with Support Programming of a Textbook," IEEE Transactions on Education, Vol. E9, No. 4, December 1966, pp. 182-187.

Kemeny, J. G., and Kurtz, T. E., "BASIC," Dartmouth College Computation Center, Hanover, New Hampshire, January 1, 1966.

Kollin, G., "Army Training Costs: Phase I. An Examination of Costs and Recording Practices at CONARC Service Schools," Technical Paper RAC-TP-204, Research Analysis Corporation, May 1966.

Kopstein, F. F., and Seidel, R. J., "Computer Administered Instruction Versus Traditionally Administered Instruction: Economics," HumRRO Professional Paper 31-67, Human Resources Research Office, The George Washington University, June 1967, 43 pp.

Kurpieski, B.S., "The Effectiveness of a Modified Classroom Communicator in the Study of Learning and Retention," unpublished doctoral dissertation, University of Oklahoma, 1958.

Lewis, L.A., "A Comparison of Visual Display in a Computer-Assisted Instruction Situation," unpublished Master's thesis, Florida State University, December 1965, 55 pp.

Lindquist, E.F., Design and Analysis of Experiments in Psychology and Education, Houghton Mifflin Co., Boston, Massachusetts, 1953.

Mager, R.G., and Clark, C., "Explorations in Student Controlled Instruction," Psychological Reports, Vol. 31, 1963, pp. 71-76.

Maher, A., "Computer-Based Instruction (CBI): Introduction to the IBM Project," IBM Research Report RC 1114, White Plains, New York, 1964.

Maruyama, M., "The Use of Computers as Industrial Counselors," Computer and Automation, July 1966, pp. 34-39.

McCarthy, J., Abrahams, P.W., Edwards, D.J., Hart, T.P., and Levin, M.I., "LISP 1.5 Programmer's Manual," The Computation Center and Research Laboratory of Electronics, Massachusetts Institute of Technology, Cambridge, Massachusetts, February 1965.

Mitzel, H.E., "The Development and Presentation of Four College Courses by Computer Teleprocessing," Final Report, Computer-Assisted Instruction Laboratory, Pennsylvania State University, College of Education, June 30, 1967.

Mitzel, H. E., and Brandon, G. L., "Experimentation with Computer-Assisted Instruction in Technical Education," Semi-Annual Progress Report, Computer-Assisted Instruction Laboratory, Pennsylvania State University, College of Education, June 30, 1967. Report No. R-6.

Mitzel, H. E., and Wodtke, K. W., "The Development and Presentation of Four Courses by Computer Teleprocessing," Interim Report, Computer-Assisted Instruction Laboratory, Pennsylvania State University, College of Education, June 1965.

Moore, C. L., and Jaedicke, R., Managerial Accounting, South-Western Publishing Company, A90, 1963.

Moore, O.K., "Autotelic Responsive Environments and Exceptional Children," Responsive Environments Foundation, Hamden, Connecticut, September 1963.

Naval Air Technical Training Command, "Cost Per Student Report, Estimated Course Costs, FY 1967," Internal Controller's Report, Memphis, Tennessee.

Pask, G., "A Teaching Machine for Radar Training," Automation Progress, Vol. 2, 1957, pp. 214-217.

Pask, G., "Electronic Keyboard Teaching Machines," Education and Commerce, Vol. 24, 1958, pp. 16-26.

Pressey, S.L., "A Simple Apparatus Which Gives Tests and Scores -- and Teaches," School and Society, Vol. 23, pp. 373-376 (March 20, 1926), cited in Betts (1966).

Pressey, S.L., "A Machine for Automatic Teaching of Drill Materials," School and Society, Vol. 25, pp. 549-552 (May 7, 1927), cited in Betts (1966).

Quinn, P.L., and Richardson, W.M., Faculty Course in Educational Technology - A Review and Guide, Academic Computing Center, U.S. Naval Academy, June 1967.

Rajartanam, N., Cronbach, L., and Glaser, G., "Generalizability of Stratified-Parallel Tests," Psychometrika, Vol. 3, 1965, pp. 39-56.

Raphael, B., "A Computer Program Which 'Understands', Proceedings Fall Joint Computer Conference, American Federation of Information Processing Societies, 1964.

Rath, G. J., Anderson, N. S., and Brainerd, R. C., "The IBM Research Center Teaching Machine Project," Automatic Teaching: The State-of-the-Art, edited by E. Galanter, John Wiley and Sons, New York, 1959, pp. 117-130.

Schramm, W., The Research on Programmed Instruction -- An Annotated Bibliography, U. S. Department of Health, Education and Welfare, Office of Education, OE34034, 1964, No. 35.

Schurdak, J. J., "An Approach to the Use of Computers in the Instructional Process and An Evaluation," American Educational Research Journal, Vol. 4, No. 1, January 1967, pp. 59-73.

Schwartz, H. A., and Haskell, R. J., "A Study of Computer-Assisted Instruction in Industrial Training," IBM Technical Report 00.1419, March 14, 1966.

Shuford, E. H., "Cybernetic Testing," presented to the National Society for Programmed Instruction in Philadelphia, May 1965.

Skinner, B. F., "The Science of Learning and the Art of Teaching," Harvard Educational Review, Vol. 24, No. 2, 1954, pp. 86-97.

Skinner, B. F., "Teaching Machines," Science, Vol. 128, 1958, pp. 969-977.

Stoker, H. W., and Hartford, D. L., "Computer-Assisted Instruction Project at Florida State University, September 1964 - August 1965," Computer-Assisted Instruction Center, Institute of Human Learning, Florida State University, August 1965.

Stolurow, L. M., Teaching by Machine, U.S. Department of Health, Education and Welfare, Office of Education, 34010, 1961, 173 pp.

Stolurow, L. M., "Some Educational Problems and Prospects of a Systems Approach to Instruction," Training Research Laboratory Technical Report No. 2, University of Illinois, March 1964.

Stolurow, L. M., "Model the Master Teacher or Master the Teaching Model," Training Research Laboratory, Nonr 3985(04), Technical Report No. 3, University of Illinois, 1964.

Stolurow, L. M., "Systems Approach to Instruction," Training Research Laboratory Technical Report No. 7, University of Illinois, July 1965. (AD-619186)

Stolurow, L. M., and Davis, D., "Teaching Machines and Computer-Based Systems," Teaching Machines and Programmed Learning, Vol. II, Data and Directions, edited by R. Glaser, National Education Association, 1965, pp. 162-212.

Stolurow, L.M., and Lippert, H.T., "Automatically Translating Heuristically Organized Routings: AUTHOR I," Technical Memorandum No. 21, Training Research Laboratory, University of Illinois, February 10, 1966.

Stygar, P., "RAID (Alias TVDDT)," Memo No. 37, Stanford Time-Sharing Project, Stanford University, November 2, 1965.

Suppes, P., "Computer-Assisted Instruction in Schools; Potentialities, Problems, Prospects," Technical Report No. 81, Institute for Mathematical Studies in the Social Sciences, Stanford University, October 29, 1965.

Suppes, P., Jerman, M., and Groen, G., "Arithmetic Drills and Review on a Computer-Based Teletype," Technical Report No. 83, Institute for Mathematical Studies in the Social Sciences, Stanford University, November 5, 1965.

Swets, J., and Feurzeig, G.W., Bolt, Beranek and Newman, "Computer Aided Instruction," Science, Vol. 150, October 1965, pp. 572-576.

System Development Corporation, "Users Guide to PLANIT - Programming Language for Interactive Teaching," Technical Memorandum, TM-3055/000/00, Santa Monica, California, July 1966, 15 pp., cited in Betts (1966).

Tallmadge, G.K., and Shearer, J.W., "Study of Training Equipment and Individual Differences," American Institutes for Research, Palo Alto, California, March 1967.

Thorndike, E.L., Educational Psychology, Vol. 11, The Psychology of Learning, Teachers College, Columbia University, New York, 1913, pp. 1-4, cited in Betts (1966).

Thorndike, E.L., Fundamentals of Learning, New York, Bureau of Publications, Teachers College, Columbia University, 1932.

Thorndike, E.L., and Hagen, L., Measurement and Evaluation in Psychology and Education, 2nd edition, John Wiley and Sons, Inc., New York, 1961, 602 pp.

Tiedeman, D.V., "The Versatile Computer is a Counselor," American Education, Vol. 3, No. 10, U.S. Department of Health, Education and Welfare, November 1967.

Uhr, L., "The Compilation of Natural Language Text into Teaching Machine Programs," Preprint 128, Mental Health Research Institute, The University of Michigan, August 1964, 18 pp.

U.S. Department of Health, Education and Welfare, "Digest of Educational Statistics, 1966," OE-100024-66, U.S. Government Printing Office, Washington, D. C., 1966.

USCONARC, "Fiscal Year 1967 Course Attrition of Army Service Schools," NO 350-6, Headquarters, United States Continental Army Command, Fort Monroe, Virginia, December 1967.

USCONARC, "Technical Development Plan: Computer-Assisted Instruction in Electronics Training," CSCRD-21 (RI), Fort Monroe, Virginia, August 12, 1966, 17 pp.

USCONARC, "Training, Student Performance Objectives," NO 350-14, Headquarters, United States Continental Army Command, Fort Monroe, Virginia, December 1966, pp. 10-17.

Uttal, W. R., "My Teacher Has Three Arms," IBM Research Report RC 788, Yorktown Heights, New York, September 1962, 42 pp.

Weisenbaum, J. F., "ELIZA - A Computer Program for the Study of Natural Language Communication Between Man and Machine," Communications of the ACM, Vol. 9, No. 1, January 1966, pp. 36-45.

Whitted, S.H., Weaver, E.E., and Foley, J.P., "Development and Experimental Evaluation of an Automated Multi-Media Course on Transistors," AMRL-TR-66-142, Aerospace Medical Research Laboratories, Air Force Systems Command, September 1966.

Wing, R. L., "Computer-Controlled Economics Games for the Elementary School," Audiovisual Instruction, Vol. 9, 1964, pp. 681-682.

Wirth, N., "PL360, A Programming Language for the 360 Computers," Journal of the Association for Computing Machinery, Vol. 15, No. 1, January 1968, pp. 37-74.

Wodtke, K.H., "Educational Requirements for a Student-Subject Matter Interface," Final Report: The Development and Presentation of Four College Courses by Computer Teleprocessing, Computer-Assisted Instruction Laboratory College of Education, Pennsylvania State University, June 1967.

Wodtke, K. H., and Gilman, D. A., "Some Comments on the Efficiency of the Typewriter Interface in Computer-Assisted Instruction at the High School and College Levels," Final Report: The Development and Presentation of Four College Courses by Computer Teleprocessing, Computer-Assisted Instruction Laboratory, College of Education, Pennsylvania State University, June 1967.

Wodtke, K. H., Mitzel, H. E., and Brown, B. R., "Some Preliminary Results on the Reactions of Students to Computer-Assisted Instruction," Proceedings of the 73rd Annual Convention of the American Psychological Association, Washington, D.C., 1965.

Zinn, K., "Computer Assistance for Instruction," Automated Education Letter, Vol. 1, 1965, pp. 4-14.

Zinn, K., "Computer Assistance for Instruction: A Review of Systems and Projects," CAI's Report 010, Center for Research on Learning and Teaching, University of Michigan, 1966.

Zinn, K., "Computer Technology for Teaching and Research on Instruction," Review of Educational Research, Vol. 37, No. 5, December, 1967, pp. 618-634.

ACKNOWLEDGMENTS

Special acknowledgment should be made to the CAI Project Group, U.S. Army Signal Center and School, for their cooperation and continuous support and guidance throughout this study. This includes the individual contributions of Col. Walter G. Runte, Project Manager, Dr. Vincent P. Cieri, Technical Director, Lt. Col. Eugene C. Davis, Jr., Lt. Ronald K. Randall, Mr. Albert J. Mizenko, Mr. Frank E. Giunti, Mr. Allyn Evans, Mr. Donald Fydrych, and Mr. Alexander A. Longo.

Acknowledgment is also extended to the members of the staff of the Department of Specialist Training and the Training Aids Division, USASCS, who participated in the support of this project.

Major IB contributors were Mr. Arthur E. Nelson, Project Manager, Mr. William C. Allison, Mr. Joseph J. Betts, Jr., Dr. Hugo A. Borresen, Miss Judith M. Huber, Mr. Joseph P. Massey, Mr. Richard C. Rivett, Mr. Jack E. Schiff, Mr. Ronald J. Silva, and Dr. Stanley Winkler. Acknowledgment is also made to Mrs. Kathryn M. Brown, Mrs. Mazada Marshall, and Mr. Laurence M. Ralston for their assistance, and to Dr. Ronald Beechler, Mr. Philip Lever, and Mr. Raymond G. Fox for their consulting services.